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RESTORATION POTENTIAL OF DEGRADED INLAND SACRED FOREST OF KACHCHH, GUJARAT: AN EVIDENCE OF SHRAVAN KAVADIYA SACRED GROVE

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ABSTRACT

Desert Ecosystems are harsh, less productive but are significant in terms of biological diversity because forest patches in desert systems play a keystone function. Indian deserts have not received the conservation attention in comparison to their counterparts as their global priorities have been low. Among the deserts, the *Orans* of Rajasthan are sacred groves revered and managed by the Bishnoi community possess a rich literature; however, the sacred groves of Kachchh region are revered because of cultural association is relatively less studied. Sacred groves provide ecosystem services through its inherent biodiversity, soil and moisture conservation, nutrient cycling, water regulation and carbon sequestration. These groves play a very important role in terms of conserving biological diversity and provide livelihood security of the local communities of arid India. The sparsely distributed sacred groves of this region face several stages of degradation by natural as well as of anthropogenic pressure. Restoration of such groves would require scientific strategy and conservation planning along with community participation. Thus, the aim of the present study is to evaluate the restoration potential of degraded sacred grove of Kachchh in comparison with the existing sacred grove of arid Kachchh by analyzing the major soil parameters of both groves.

KEYWORDS: ***Conservation, biodiversity, sacred grove, mangrove, restoration***

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INTRODUCTION

There is a wide recognition that ecological prudence exhibits symbiotic relationship between ecosystems and social systems. The existence of sacred groves is one such indicator of community based conservation and sustainable forest management, recognized and implemented by various institutions of governance[1] India is a vast country with rich biodiversity due to varied physiographic and climatic regimes. It is one of 17 mega-diversity countries in the world and encompasses a wide spectrum of habitats, *viz.* tropical rainforests to alpine vegetation and coastal wetlands to desert scrub vegetation. Sacred forests are distributed across India and there have been substantial efforts in documenting these and highlighting the ecosystem services they provide[2,3]. Among the 10 biogeographic zones in India[4], the arid biogeographic zone of India which includes the state of Rajasthan and the north-western parts of Gujarat state, requires greater attention for conservation of sacred forests due to its existence in extreme climate. Sacred forests in this zone specifically are inventoried and partly documented[5] but the vulnerability of the groves to ongoing climate change and anthropogenic pressure and their restoration potential in this region has not been adequately studied. A detailed comparative analysis of the sacred groves of hot deserts of the world has been given by (Pandey & Mahato, 2019) in which the age old traditional practice of revering these forests of reverence has been well documented[6]. Therefore, an attempt was made to assess the threats and restoration potential of the sacred forests on this arid Kachchh region of Gujarat, India, which have two unique sacred inland mangrove i.e. Shravan Kawadia and Guneri mangroves.

MATERIAL AND METHODS

Ecological significance of Kachchh

Rann of Kachchh is one of the largest saline and marshy tracts of the world. Rann of Kachchh is located in a low and erratic rainfall zone with arid climate having sparsely distributed thorny and halophytic vegetation. However, this region has a distinctive bio-geography as it lies along the coastline of the Gulf of Kachchh in the south and Thar Desert on the north. Rann of Kachchh is inherently a saline regime due to its origin from an estuary in geological past and influx of sea water from high tides of the Gulf of Kachchh and Arabian Sea. This uniqueness makes Rann an important biodiversity area due to the presence of varied vegetation, endemic and threatened species of animals and breeding ground for thousands of migratory flamingos[7]

Mangroves and their significance

Mangroves and associates play a keystone function on coastal ecosystems. They function as nursery and breeding ground for - fish, crustaceans and diverse marine species. They are also an important carbon dioxide sink known as blue carbon. Mangroves can generally grow in between low tide and high tide regions of the coastal areas[23]. In the recent days, mangroves face several threats due to rapid development in coastal areas around the world and the ongoing climate change. In many coastal areas, mangrove forests are threatened due to intensive shrimp farming, exploitation of wood and fodder including human settlement. The sea level rise impact on many mangroves species, among which *Avicennia*, a species of concern in many parts of world[8]. *Avicennia marina,* a mangrove species which predominates the coastal areas of Kachchh is categorized as Least Concern species by IUCN due to its wide distribution in India as well as the world. It is a medium-sized bushy tree of 2-5 m height found at the mouth of rivers and streams or in lower tidal ranges along coastal areas and it can survive in a salinity of 0-30 ppt[8]. As a pioneer species, *Avicennia marina* is highly tolerant of extreme saline conditions as it actively resists the uptake of salt at the roots. *Avicennia* spp. can also withstand short periods of inundation of freshwater or hyper saline water.

Inland mangroves of Kachchh and their threats

Gulf of Kachchh in India is adorned with huge mangrove existence with an area of 980 km^2. Mangroves are generally classified on the basis of hydrodynamic exchange and are also considered as a euryhaline species. Mangroves are completely associated with the sea water and they get their nutrient requirements from it. Due to changing weather and inclement conditions there are a few mangroves which get either low or no direct connection to the sea water and hence they are called as *Inland mangroves*. Scientific literature fathoms the existence of very few species of inland mangrove, especially in lagoons, deltas, islands and on the fringes of the water bodies. As per their surviving habitat, the inland mangroves attain a high ability to endure the dry conditions and in fact a total disconnection from the sea. On the basis of their proximity with water, the inland mangroves have existed in patches around the world like Australia, Antigua-Barbuda, Bahamas, Guatemala, Indonesia, Mexico and Pakistan[9]. In India, the Kachchh district of Gujarat shows an enigmatic existence of inland mangrove in Shravan Kawadiya and Guneri both of which are completely land-locked. The assortment of these mangroves as inland dates back to two millennia when the Rann of Kachchh was a shallow sea. Due to the receding water year after year, the dried land got lifted up due to tectonic shift giving rise to the phenomena of “inland” mangroves The receding of Arabian Sea by 100-150 km from the coastline resulted in Guneri and Shravan Kawadia groves. Therefore, the surviving mangrove patch in Shravan Kavadia belongs to one of the ancient bio-genetic pools[10]. Naturally mangroves are propagated through the dispersal of seeds and propagules via sea water. It is because of this reason that the inland mangrove patches have become one of the major interests of the researchers from geological point of view. The inland mangrove of Guneri, especially *Avicennia marina* species, survives due to the sub-terrain hydrological connects with saline water. The inland mangrove forests of Kachchh are threatened by the consequence of geo-morphological events of the past[11] The majority of inland mangrove in Shravan Kawadia was destroyed due to cyclone in 1998 and the rest of the mangrove stand was destroyed by the attack of wood borer and might be due to the lack of saline water from sub-terrain connection and climatic phenomena. The threats and level of degradation in inland mangroves of Guneri and Shravan Kavadiya are different. In Guneri, the decimation of the inland

mangrove is minimal as the mangrove leaves are collected by the cattle grazers during the drought years which are reported to occur in Kachchh once in four years[12]. The inland mangroves of Shravan Kawadia are now completely decimated although they were revered by the local communities. Both the inland forests of Kachchh are unique and reported peculiar in terms of the habitat extremity among the eight inland mangroves of the world.

Restoration initiatives of degraded mangrove forests in India with a focus on Gujarat

In India, mangrove forests are distributed along 6740 km^2 of area[13]. The vast majority of which has been extremely overexploited. Mangroves in the tropics are reported to recover themselves or be re-established utilizing low-innovation propagule planting, parched mangroves (which are areas having restricted or no entrance to new water) can occasionally recover by rain or underground water, although this happen slowly[14] . Bosire *et al*. (2008) reviewed the available retrospective methods of mangrove restoration and highlighted the trans-disciplinary approaches of combining the basic and applied sciences on the one hand, and social and human sciences on the other[15]. The Gulf of Kachchh of Gujarat in India is extensively rich in mangrove forests which amounts to23% of mangrove distributed in India. *Avicennia marina* is the favoured species in this region due to its ecological versatility. In the Gulf of Kachchh, three diverse methods for plantation have been used *viz.* (a) transplantation of nursery-raised saplings, (b) raised bed strategy, and (c) coordinate propagule dibbling, among which transplantation of nursery-raised saplings is considered as best. Numerous uncertain issues, for example, high occurrence of mortality, poor site selection, inadequate capacities and legal hassles in getting proper locales cripple mangrove ranch in the Gulf[16].

Suitable species for mangrove restoration.

There are many restoration initiatives in India among which three species of *Avicennia* were suggested and used for the restoration by different workers. Das *et al.* (1997) discussed the property of *Avicennia officinalis* in Odisha with respect to its vegetative propagation, easy growth pattern and high salinity tolerance which makes this genus an indicator of efficacious mangrove cultivation[17]. Bashan et al. (2002) emphasized that *Avicennia* is one of the prime species for mangrove restoration since it is important for nitrogen fixation and the leaves get easily decomposed which in return increases the soil fertility and nutrients and thereby helps in self perpetuation of it[18]. Selvam *et al*. (2012) used two different species of *Avicennia* for restoring a degraded land in Andhra Pradesh, *A. alba* and *A. marina*. *A. marina* is the most common species suitable for mangrove restoration in the degraded areas. This species has the ability to tolerate salinity up to 90 ppt[19].

Description of the Study Area

The Gujarat State is divided into four regions with distinct climate, vegetation and soil physical conditions i.e. North and Central Gujarat, South Gujarat, Saurashtra and Kachchh. Kachchh has few sacred groves reported in some parts of the district (Figure 1). Kachchh happens to be the largest district of India having a total area of 45652 km^2. Of this, Rann of Kachchh covers an area of about 30,000 km^2 which makes 2/3 of the area. Kachchh also has the longest coastline of 1500 km^2 with rich biodiversity inclusive of mangroves, coral reefs, mudflats, seaweeds, commercial fishing opportunities and several rare marine fishes. The coastline of Kachchh is conducive to various marine based traditional occupations viz. Fishing, extraction of salt for commercial uses, agriculture, horticulture and animal husbandry[20]. The religious and cultural practices of the people of Kachchh incorporate the use of many plant species and plant parts. Though sacred groves are few in Kachchh, they are being worshipped by the indigenous people. The sacred groves not only have religious or cultural values but also more practical purpose of preserving the islands of biodiversity[21].

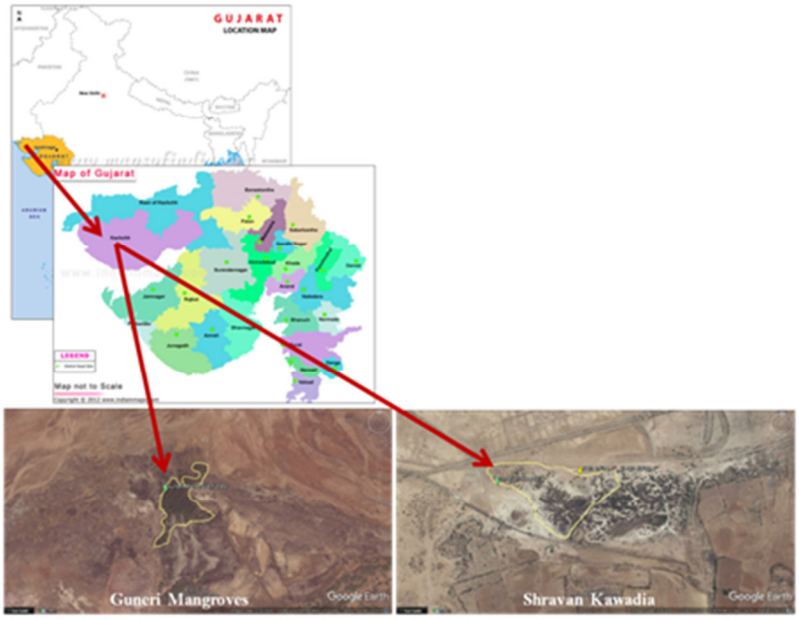


Figure 1
Cartographic representation of the study area.

Guneri and Shrawan Kawadia are inland sacred mangroves. Guneri is believed to be the site for pilgrims to rest on their journey to Hinglaj Mata, holy place of worship presently located in Pakistan[22]. Shrawan Kanvadiya is believed to be the site where Shravan Kumar, the mythical character from the Ramayana, was shot to death with an arrow by King Dasharatha. Shravan Kavadiya which was recorded as the first inland mangrove forest in India[23] is now extinct due to the attack of the wood borer and loss of inherent saline water in the area (see figure 2a.) and is regarded as degraded whereas Guneri, the only inland mangrove left in India and this happens to be the major reason behind selecting the said study. The sacred groves have been selected on the basis of the soil quality if the habitat they are located and also the underground water availability.

(a) Degraded Avicennia marina at Shravan Kavadiya ***(b) Degraded Shravan Kavadiya***

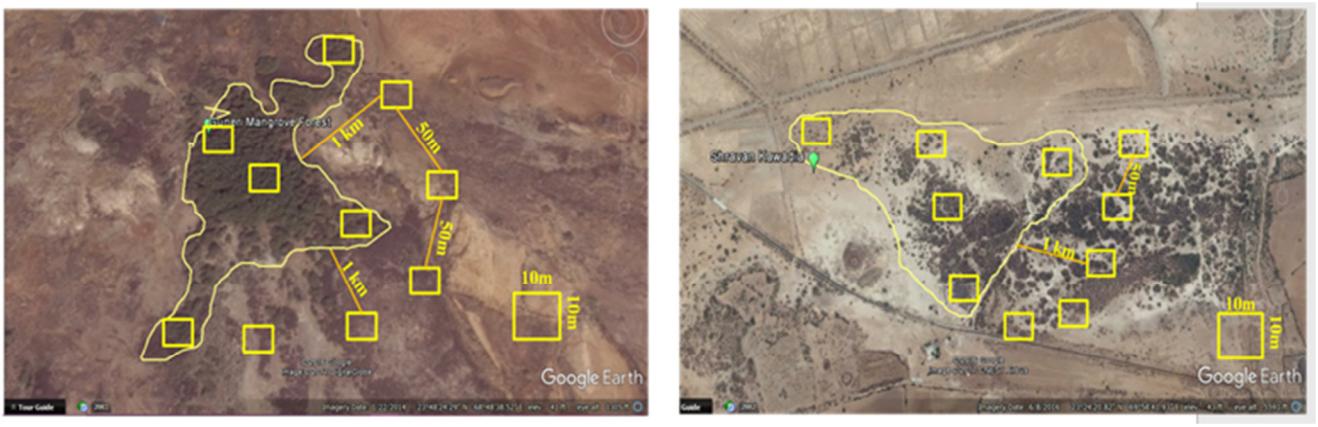
(c) Guneri mangrove forest

Figure 2
Glimpses from the onsite existence of the selected sacred groves

Methodology
The study was made with three important components: 1) Secondary data collection 2) Primary data collection and 3) Analysis and integration of the data. The detailed methodology followed is described as follows:

Secondary data collection
Secondary information related to sacred groves in general and from the desert of India has been collected to identify all the article potent for making the review efficacious in providing complete analogy on sacred groves and restoration of degraded groves found in desert areas all over the world. The critical review of the available information led on to the restoration activities on the sacred groves of Kachchh, Gujarat. The existing information about the sacred groves of Gujarat has also critically reviewed to find out the conservation activities done on the restoration of sacred groves and sacred mangrove.

Field Survey and Soil Sampling
Field visits to the Sharvan Kavadiya and Guneri Inland mangrove were made during the pre-monsoon, monsoon and post monsoon period of the year 2017-18. The location of inland mangrove sites and soil sampling sites were noted using GPS and are used to locate the sites on preparation of the satellite map. Soil samplings were made within and outside the inland groves in a depth of 25 cm (Figure 3 a & b.):



(a) Guneri mangrove forest *(b) Shravan Kawadia sacred grove*

Figure 3
Sampling strategy of the study

Soil samples were collected from the 5 plots that were laid to study the regeneration status of the species.

Analysis and integration of the data

The soil characteristics and the physico-chemical properties were analyzed to understand the rejuvenation potential of vegetation in general and in specific to *Avicennia marina* on the degraded inland mangroves. The soil characteristics such as pH, moisture, organic carbon, organic matter, salinity and electrical conductivity (EC) of collected soil analyzed using methods as per the recommendations of AboEl-Nil (2001) and Ramasubramanian (2004)[24]. Organic carbon was calculated using Walkley and Black Wet digestion technique.

STATISTICAL ANALYSIS

This section provides planning, designing, collection of data and analysis of the data giving rise to the interpretation of the study and reporting of the research inference. This manuscript will help the reader acquaint with the outline of the variables and the measurement of central tendency. The sample was collected using random sampling method wherein the researcher collected soil samples inside and outside the sacred groves (5 samples each) in order to the how the samples get affected with respect to the vegetation. The samples outside the groves were collected up to a distance of 1 km. The collected sample were composited and then with the help of biodiversity pro 2.0 software were analyzed to find out the error and average mean of the total samples collected. Soil Quality was determined on the basis of pH, Electrical Conductivity and Salinity, and soil moisture using Electrode method and Gravimetric method[1] accomplished at TERI-SAS laboratory.

RESULTS AND DISCUSSION

A composite sampling was done in order to examine the soil characteristics. Table 1 represents the physic-chemical results of the soil samples from the two selected sacred groves.

Table 1
Results of soil parameters

Soil Parameters	Guneri Mangrove Forest										Shravan Kawadia									
	Within the grove					Outside the grove					Within the grove					Outside the grove				
	S_1	S_2	S_3	Mean	Std.dev.	S_1	S_2	S_3	Mean	Std. dev.	S_1	S_2	S_3	Mean	Std. dev.	S_1	S_2	S_3	Mean	Std dev.
pH	6.92	6.87	6.91	6.9	±0.03	6.67	6.5	6.68	6.62	±0.10	6.34	6.20	6.33	6.29	±0.08	6.10	6.90	6.98	6.66	±0.49
Electrical Conductivity (milli seimens)	38.1	37.43	38.00	37.84	±0.36	47.7	46.89	47.66	47.42	±0.46	62.6	63.01	61.91	62.51	±0.56	64.8	65.01	64.78	64.86	±0.13
Moisture (%)	56.78	55.85	57.77	56.8	±0.96	55.53	54.98	55.97	55.49	±0.50	6.68	6.96	5.99	6.54	±0.50	2.73	2.89	2.66	2.76	±0.12
Salinity (ppt)	24.38	2.42	2.39	9.73	±12.68	30.52	30.52	30.51	30.51	±5.13	40.06	39.98	40.06	40.03	±42.46	41.47	41.46	41.47	41.46	±5.29
Organic Carbon (%)	15.6	15.1	15.5	15.4	±0.26	9.7	9.6	9.7	9.67	±0.06	3.09	3.00	3.10	3.06	±0.06	1.36	1.33	1.35	1.35	±0.02

S_1, S_2, S_3 = Triplicates of the collected soil samples from inside and outside the grove.

Soil properties

Soil pH

pH defines the acidity and alkalinity of the soil which makes it more conducive to entertain healthy vegetation of mangroves. The analysis of the soil sample revealed that the pH of the soil inside the inland mangrove sacred grove in case of Guneri which contains the dense vegetation of mangroves is less than that of what prevails in degraded Shravan Kavadiya (Figure 4 (a))

Soil electrical conductivity (EC)

It is the measurement of the amount of salt content in the soil which further defines the overall vegetational ability and health of the soil. Specifically for the mangroves vegetation, it is the amount of essential salts required for the sustenance of the mangrove. EC in both the cases (Table 2) has been higher outside the sacred grove. This gives the inference that mangroves consume the available nutrients and salts for its sustenance whereas the region in which there are no mangroves. Also, the salinity of the soil is high which leads to the excessive accumulation of the salts content thereby making the soil less conducive to vegetation, hence the presence of mangroves on such land is highly recommended. (Figure 4 (b))

Soil Moisture

Basically it is the proof of the water holding capacity and percolation of the soil in a given particular region. It furthers ensures the health of the soil in terms of nutrients and gaseous exchange which is significant in keeping a healthy vegetation. Guneri mangrove forest shows better soil quality to entertain the mangrove population whereas despite of being deserted, Shravan Kavadiya needs an immediate cultivation of mangroves in order to restore the land leading to the safeguard of one of the important ecosystems of Kachchh. (Figure 4 (c))

Soil Salinity

It is the measurement of the salt content in the soil which can be due to natural process of weathering of rocks or by the receding sea water. Due to the receding sea water in both the sacred groves, the chances of salinization is high but the results revealed that the presence of mangroves has successfully maintained the optimal level of salinity content in Guneri whereas in Shravan Kavadiya it is extremely high due to the paucity of mangroves. This again urges the need of reintroduction of mangroves in order to restore the land. (Figure 4 (d))

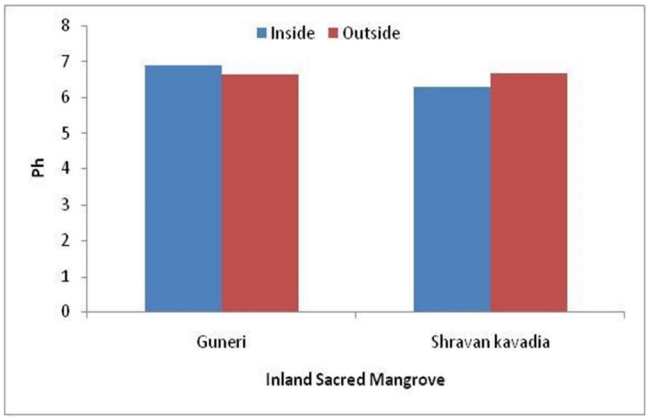
Soil Organic Carbon

It is the carbon stored in soil which is the result of the utilization of carbon-di-oxide by plants during photosynthesis. High percentage of organic carbon indicates of the presence of a healthy vegetation whereas low percentage indicates the poor fertility of soil. In the present study, the percentage of organic carbon is higher in the mangrove prone region whereas it is remarkably low in the other. This is another reason that reveals the significance of mangroves in xeric habitat, keeping the vegetation sustained and also the restoration of degraded land. (Figure 4 (e))

Table 2

Inferences of the soil parameters for the selected sacred groves

Soil Parameter	Guneri Mangrove		Shravan Kavadiya	
	Mean inside ± Std.dev.	Mean outside ± Std.dev.	Mean inside ± Std.dev.	Mean outside ± Std.dev.
pH	6.9 ± 0.03	6.62 ± 0.1	6.29 ± 0.08	6.66 ± 0.49
Electrical Conductivity (milli seimens)	37.84 ± 0.36	47.42 ± 0.46	62.51 ± 0.56	64.86 ± 0.13
Moisture (%)	56.8 ± 0.96	55.49 ± 0.5	6.54 ± 0.50	2.76 ± 0.12
Salinity (ppm)	9.73 ± 12.68	30.51 ± 5.13	40.03 ± 42.46	41.46 ± 5.29
Organic Carbon (%)	15.4 ± 0.26	9.67 ± 0.06	3.06 ± 0.06	1.35 ± 0.02



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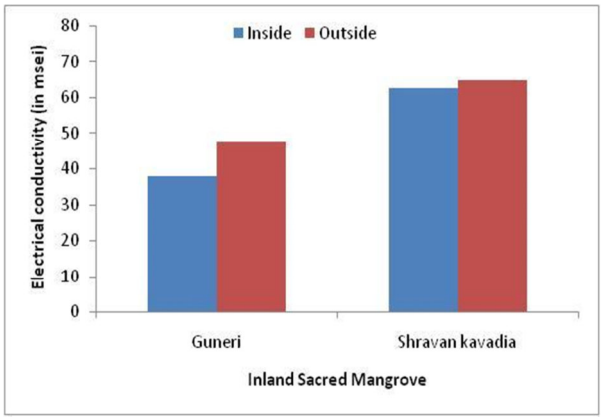

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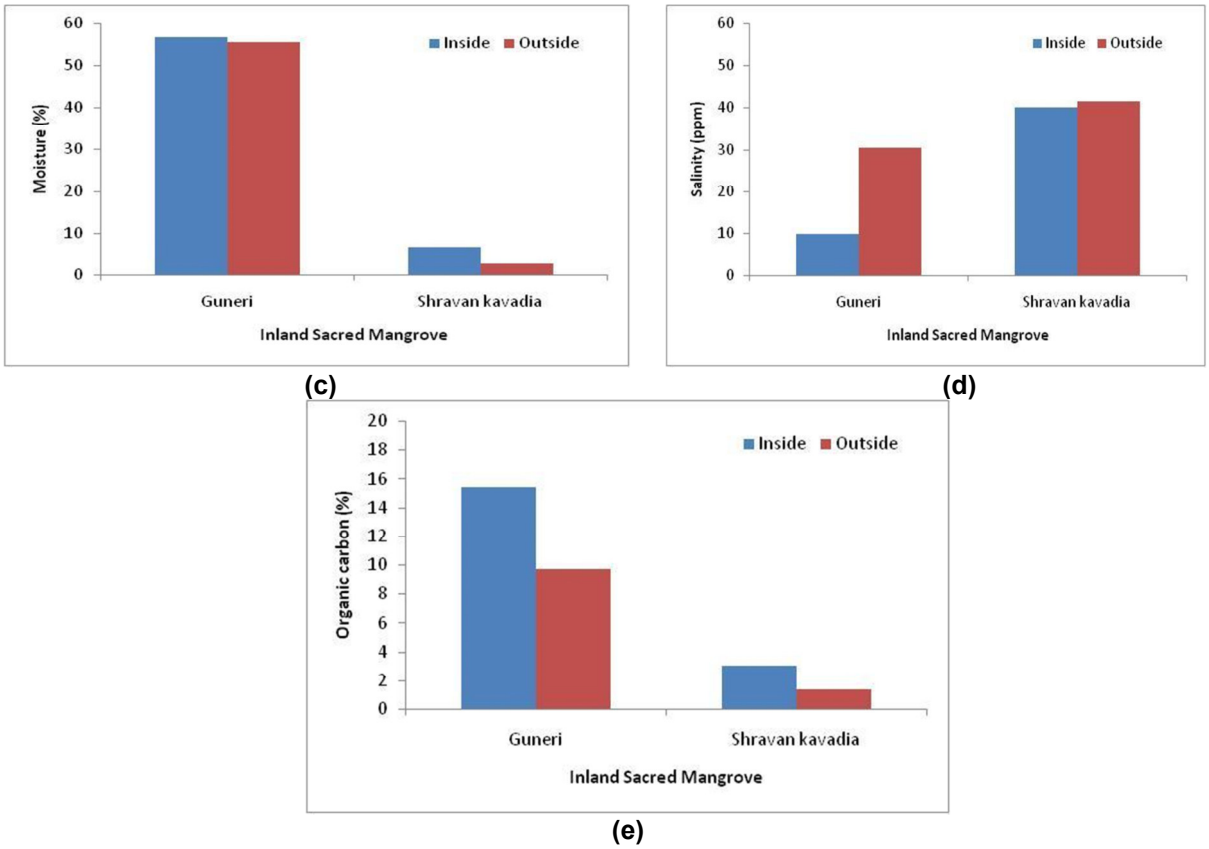

Figure 4
Graphical illustration of the comparative analysis of various soil parameters from the study site

Avicennia marina is the mangrove species which is abundant in most of the coastal regions and is also easy for plantation and restoration. *Avicennia* prefers moderate to low level of salinity for its growth and survival. The comparative analysis of the various soil parameters of the two selected inland mangrove revealed that salinity is reported to be an important parameter for the growth and survival. The salinity level inside the inland mangroves of Guneri was recorded as 9.73 ppm whereas the salinity outside the mangrove was recorded as 30.51 ppm. While in Shravan Kavadiya (now degraded land), the salinity content of soil inside the grove was recorded as 40.03 ppm, and outside was recorded as 41.46 ppm. The percentage of organic carbon was recorded high (15.4 %) within the Guneri inland mangrove while it is recorded low (9.67%) outside the inland grove area. The organic carbon content within (3.06%) and outside (1.35%) the inland mangrove of Shravan Kavadiya was recorded very low compared to Guneri. The difference in salinity content of the soil within and outside inland mangrove might be due to the absorption of salinity by the *Avicennia marina* resulted to low salinity within the grove while high salinity outside the mangrove due to absence of *A. marina*. The lack of mangrove vegetation resulted in low level of carbon content outside inland mangrove while it showed high level of organic carbon inside the mangrove due to the presence of *A. marina*.

CONCLUSION

The inland mangrove as sacred grove pave way for long term ecological monitoring and conservation of these patches of community revered forest patches. The aforesaid study is therefore significant specifically in considering the arid biogeographic province of India. *Avicennia marina* happens to be the most abundant mangrove species in Kachchh topography. The study has unveiled the reason behind the natural growth of the mangrove species which is due to the high endurance level of salinity and aridity of the soil. The epidemic degradation of unique inland mangrove “Shravan Kavadiya” might be due to the ignorance of its ecological importance, natural attack of wood borer and other natural factors. The significance of the study lies in its comparative analysis of the soil parameters of two inland mangrove sacred groves out of which one has been now a degraded land. The study of these soil parameters has been an important way to understand the ecosystem and its nutrient status in order to ensure better plantation and restoration activities in degraded land associated with valuable biodiversity and its conservation. Since the soil parameters of the area has revealed favorable outcomes towards the plantation of *A. marina,* this study gives concise analogies on the restoration potential for the degraded sacred inland mangrove, Shravan Kavadiya, in order to restore the mangrove for its ecological significance, socio-cultural importance and larger scientific interest for its uniqueness as a treasure for the arid Kachchh.

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AUTHORS CONTRIBUTION STATEMENT

Mr. Amit Pandey (corresponding author) has formulated, conceptualized and documented the study right from the inception to data collection and analysis. Dr. Arun Kumar Roy Mahato (co-author) has provided the logistic support and has helped in the statistical analysis of the study. Also, he has been a great support in providing relevant literatures. Both the authors have equally contributed towards the writing of the manuscript and finalizing the findings of the study.

CONFLICT OF INTEREST

Conflict of interest declared none

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