

## Sahyadri gourd (*Momordica sahyadrica*): a lesser-known albeit important traditional vegetable

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The World Vegetable Center, Taiwan regards traditional vegetables as one of the important means of 'climate-resilient pathways'. *Momordica sahyadrica* is a lesser-known traditional vegetable having nutraceutical virtues. It grows well under marginal input and partial shade environment, thereby, it aptly highlights one of its niche attributes, 'climate resilience'. It is endemic to the typical habitat of the Western Ghats (Sahyadri mountain range) and is a distinguished species of the well-known vegetable genus *Momordica*. Popularizing this species, conservation through cultivation, and further focused research and development using various techniques will facilitate the recovery of promising genotypes and mainstreaming of this Sahyadri gourd.

**Keywords:** Climate resilience, hermaphrodite flower, *Momordica sahyadrica*, nutraceutical benefits, Sahyadri gourd, traditional vegetables.

THE most recent position paper of the World Vegetable Center, Taiwan, highlights underutilized traditional vegetables and expresses the need for concerted efforts in their research and development<sup>1</sup>. The centre regards traditional underutilized vegetables as one of the important means of climate-resilient pathways with nutraceutical benefits. Certainly, 'climate resilience' is one of the niche attributes for becoming a future food crop.

The Western Ghats of India (Sahyadri mountain range covering Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala) is regarded as an important biodiversity hotspot among the 36 biodiversity hotspots across the world<sup>2</sup>. It is home to several native/indigenous and under-researched plant species. One of them is *Fagla*, as it is known in Goa in the local Konkani language. It has been recognized as a distinct species of the well-known *Momordica* genus, whose immature fruits are used as a vegetable. It exhibits close similarity to the spine gourd (*Momordica dioica*). So, before being identified as a separate species, the common name 'spine gourd' and the botanical name *Momordica dioica* were used for both species. However, based on several morphological and ecological features, *Momordica sahyadrica* was identified and categorized as a distinct species.

Unorganized production of *M. sahyadrica*, more precisely, availability of its fresh-fruit by means plucking from natural habitat makes its presence occasional during the season. Nevertheless, both growers and consumers are aware of the virtues of this vegetable group.

The fruits of *M. sahyadrica* at the green immature stage are used as a vegetable, and different preparations are relished by the locals during rainy/*kharif* season of fresh availability. Preparations like spicy dry dishes, semolina-coated fried strips, etc. are popular (Figure 1). To overcome the problem of seasonal availability, the fruit slices are dried for later use.

The range of species being used and available as a vegetable in the market requires further addition of new vegetables. Popularization of potential underutilized species like *M. sahyadrica* can become a new addition to market vegetables. It will diversify the vegetable basket on the one hand, as well as enhance focus on such under researched yet potential species on other hand.

The genus *Momordica* is important as a source of vegetables with nutraceutical values. It comprises more than 60 species<sup>3</sup>. Among them, *M. sahyadrica* is a dioecious species of importance, besides other well-known dioecious species like *M. dioica* (spine gourd), *Momordica cochinchinensis* (sweet gourd), *Momordica subangulata* subsp. *renigera* (teasel gourd).

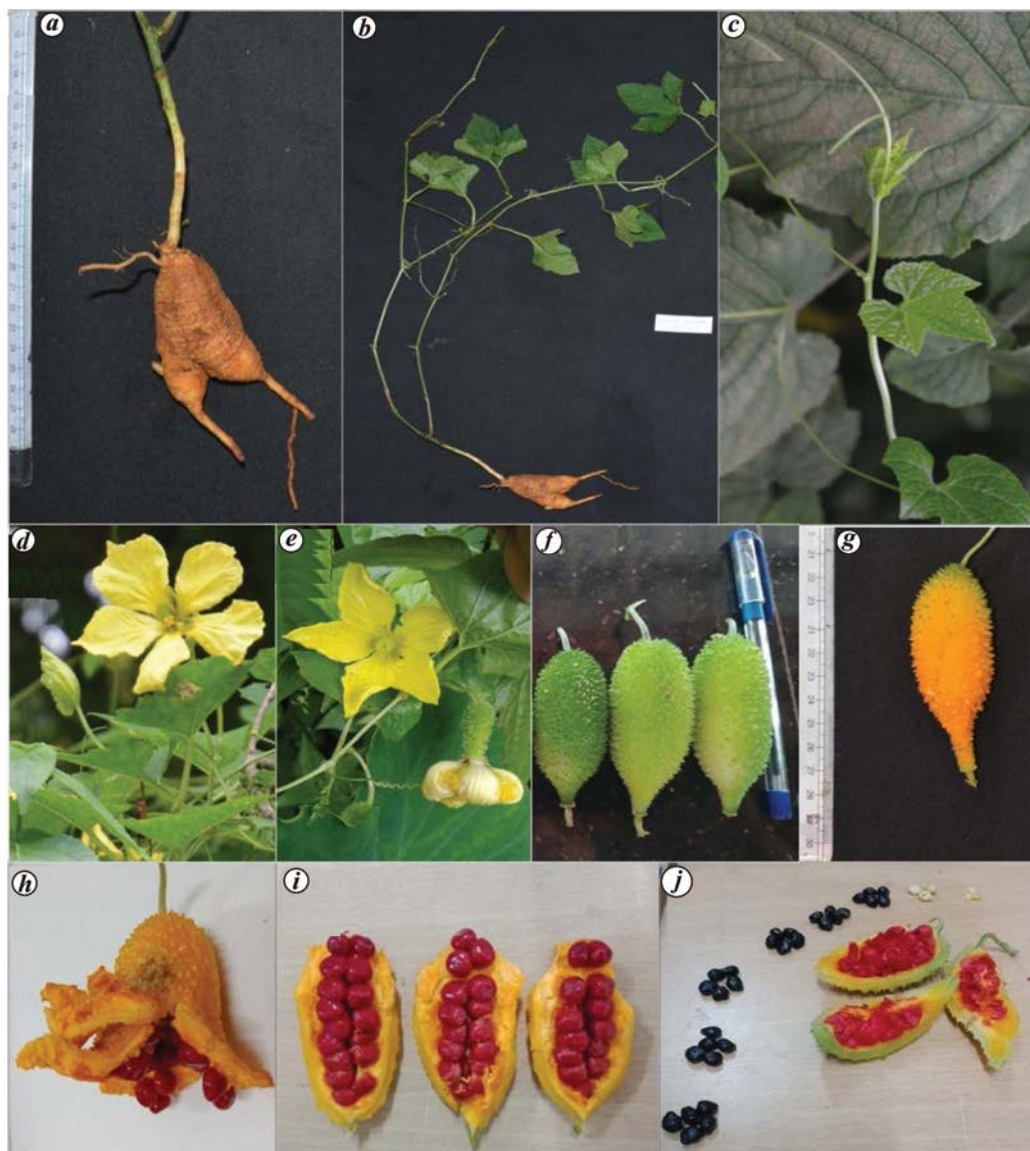
The first report elaborating *M. sahyadrica* as a distinct species based on various morphological and ecological features was published in 2007 by Kattukunnel and Antony<sup>4</sup>. The species name *sahyadrica* refers to the Sahyadri mountain range (Western Ghats), which indicates that the species is endemic to the narrow habitat range from Agastya Mala in the southernmost end of the Western Ghats in Tamil Nadu, to Radhanagari and Mahabaleswar in Maharashtra. However, its maximum occurrence was reported at higher altitudes in Goa, southern Karnataka and Kerala. Figure 2 shows *M. sahyadrica* collection from the Goa region.

*M. sahyadrica* grows on well-drained laterite slopes at altitudes 250 m amsl and is reported to occur most frequently between 600 and 850 m (ref. 4). However, it is also seen growing in the rainfed Western Ghats forest openings and under partial shade, even at lower altitudes.



**Figure 1.** Few food preparations of *M. sahyadrica*. (a) Spicy dry dish and (b) semolina-coated fried strips.

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**Figure 2.** *M. sahyadrica* in different stages of growth. *a*, Tuberous root. *b*, Tuberous root, vine stem and leaves. *c*, Growing shoot and tendrils. *d*, Male flower and bud from male vine. *e*, Female flower and bud from female vine. *f*, Marketable stage fruits. *g*, Ripened fruit. *h*, Dehiscent nature of ripened fruit. *i*, Seed arrangement and bright red seed aril. *j*, Seeds extracted from ripened fruits.

The mature fruits from female vines show dehiscent nature by ripening and disseminating the seeds that are covered under reddish arils. The seeds remain dormant till the pre-monsoon showers. The primary root becomes tuberous and functions as an underground perennating structure. The above-ground parts die on attaining senescence every year, but the perennating structure puts forth sprouts in response to the pre-monsoon showers each year. Accordingly, the life cycle of a *M. sahyadrica* vine is up to five years, following which the tuberous perennating structure decays. Flowering during every season starts 65–70 days after seed germination or sprouting of the tuber and continues up to 150–180 days. Male vines are observed to be slightly precocious in flowering.

Though *M. sahyadrica* (Sahyadri gourd) and *M. dioica* (spine gourd) appear to be similar in the general morphology of leaves and seeds, conspicuous differences exist with respect to flower colour, floral biology, fruit size and ecological habitat (Table 1).

Fruits from the dioecious *Momordica* spp. are reported to have high nutritive value, with their proximate composition per 100 g fruit being 84.10–93.00% moisture, 0.10–1.00 g fat, 1.03–3.00 g fibre, 0.60–3.10 g protein, 6.40–7.70 g carbohydrates, 29.00–52.00 calories energy as well as minerals like calcium (23.00–64.00 mg) and phosphorus (38.00–89.00 mg) (ref. 5). *M. sahyadrica*, an understudied species, must be analysed for its inherent nutritive composition to re-establish its nutritive virtue.

**Table 1.** Comparative morpho-ecological features of Sahyadri gourd and spine gourd

Features/attributes	<i>Momordica sahyadrica</i> (Sahyadri gourd)	<i>Momordica dioica</i> (spine gourd)
Habitat	Semi-evergreen and evergreen forest of the Sahyadri mountain, particularly the mid and high ranges; grows in partial shade	Grows in open forests and scrub jungles, distribution all over Central as well as Peninsular India
Natural propagation	Seeds (seed propagation gives male and female vines) and tuberous root (gives true-to-type vine)	Seeds (seed propagation gives male and female vines in the ratio of 1 : 1) and tuberous root (gives true-to-type vine)
Flower colour	Bright yellow	Dull yellow
Flower size	Big and about four times the size of <i>M. dioica</i> (around 8–10 cm in diameter)	Small (around 2–2.5 cm in diameter)
Anthesis	Early morning	Evening
Pollinators	Butterflies, carpenter bees, sunbirds, etc.	Moths
Fruit	Comparatively bigger (up to 8 cm fruit length), round, oval or oblong in shape with conspicuously pointed blossom end	Comparatively small (up to 4 cm fruit length) and round-shaped

Source: Bharathi and John<sup>9</sup>.



**Figure 3.** Evaluation of *M. sahyadrica* under partial shade.



**Figure 4.** Prolific-flowering male and fruiting female genotypes of *M. sahyadrica*. *a, b*, Profusely flowering male genotypes. *c*, Profusely fruiting female vine.

Apart from extensive use as a nutritive vegetable, the fruits of Sahyadri gourd are considered essential in making ‘*Matoli*’ (a traditional decorative arrangement for displaying the biodiversity profile of the locality) during the Ganpati festival celebrations in the Konkan area. In Hassan district, Karnataka, a vegetable dish prepared using potato, chickpea, and *M. sahyadrica* fruits is a must for Ganpati Pooja. A prasadam – curry or rasam – made using *M. sahyadrica* fruit is served in Shimoga area, Karnataka during pooja. The medicinal uses of *M. sahyadrica* are well known among the tribes like Malayarayar, Gowli and Jainu Kurbas<sup>6</sup>.

In spite of the above-mentioned uses of Sahyadri gourd, its cultivation is not commercially explored. Primarily, Sahyadri gourd needs a change from wild and semi-domesticated habitat to a domesticated habitat that matches the growing environmental parameters for it to thrive (Figure 3), and also helps adopt standard production practices.

The ICAR-National Bureau of Plant Genetic Resources (NBPGR) holds a good collection of *M. sahyadrica*. It is a

dioecious species and therefore, there are separate male vines that act as a source of pollen grains and female vines that can only bear fruits post-pollination. It is thus evident that prolific-flowering female genotypes are considered promising; however, the unavailability of sufficient pollen grains and poor pollination by pollinators lead to female flower drops and abnormal misshapen fruits. Therefore, the prolific-flowering male genotype of *M. sahyadrica* is a pre-requisite to act as an efficient pollen source in the ratio 8–10 : 1 (8–10 female vines : 1 male vine), to result in better fruit setting on the female vines (Figure 4).

A spacing of 1.5–2 m × 1.5–2 m can be adopted and well-decomposed farmyard manure is usually applied every year, which needs to be standardized further for harvesting higher yields with quality and economic feasibility. It is noteworthy that research institutions in India have already developed improved varieties of other dioecious *Momordica* species (Table 2), indicating such research prospects for improvement in the Sahyadri gourd.

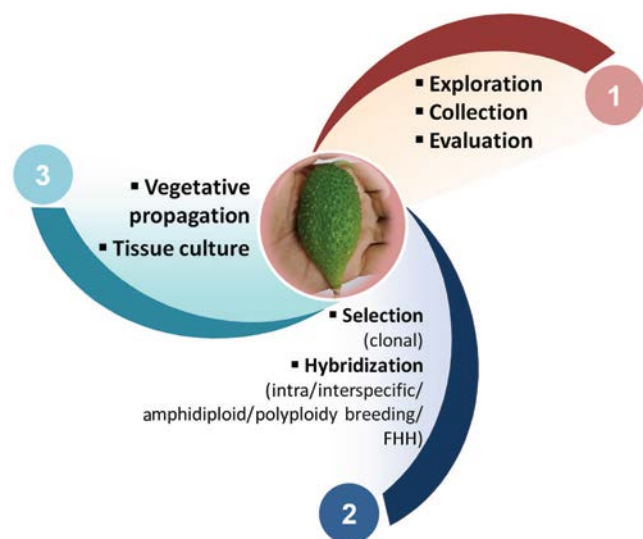
To bridge the research gap, techniques like exploration in the Western Ghats forests, and collection of *M. sahyadrica* genotypes from their natural habitats need to be given emphasis. Besides, *M. sahyadrica* genotypes can also be assimilated from the NBPGR for their utilization in crop improvement. Further, procedures for selection and intra-specific hybridization, etc. can be adopted to develop promising genotypes (Figure 5). The cytotaxonomical analysis confirmed that *M. sahyadrica* has  $2n = 28$  chromosomes as reported in *M. cochinchinensis* and *M. dioica*<sup>7</sup>. Thus, the possibility of inter-specific hybridization can also be explored to tap its enhanced genetic potential. Another important dioecious species *M. subangulata* subsp. *renigera* has exactly double the number of chromosomes ( $2n = 56$ ) compared to *M. sahyadrica*. Thus, the possibility of amphidiploids development and polyploidy breeding can be explored for developing new genotypes.

Spray application of 500 ppm silver nitrate ( $\text{AgNO}_3$ ) on female vines of *M. sahyadrica* successfully induced hermaphrodite flowers (Figure 6), while the male vines were found to be non-responsive to the application of  $\text{AgNO}_3$ . By

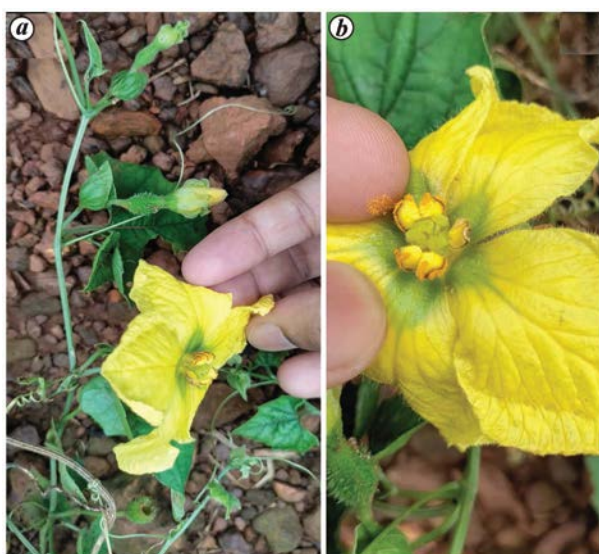
**Table 2.** Varieties developed in dioecious *Momordica* spp. by different organizations

Crop/details	Botanical name	Variety developed	Institution/university where developed
Spine gourd	<i>Momordica dioica</i>	Indira Kokonda 1	IGKV, Raipur, India
Teasel gourd	<i>Momordica dioica</i>	Arka Neelachal Shree	CHES, Bhubaneswar (ICAR-IIHR India)
	<i>Momordica subangulata</i> subsp. <i>renigera</i>	Arka Neelachal Gaurav	CHES, Bhubaneswar (ICAR-IIHR India)
Sweet gourd	<i>Momordica subangulata</i> subsp. <i>renigera</i>	Arka Bharath	ICAR-IIHR India
	<i>Momordica cochinchinensis</i>	Arka Neelachal Arakta	CHES, Bhubaneswar (ICAR-IIHR India)
Successful interspecific cross	<i>Momordica dioica</i> × <i>Momordica subangulata</i> subsp. <i>renigera</i>	Arka Neelachal Shanti	CHES, Bhubaneswar (ICAR-IIHR India)

Source: IGKV<sup>10</sup> and ICAR-IIHR<sup>11</sup>.



**Figure 5.** Approaches for the development of promising genotypes and mainstreaming of *M. sahyadrica*.



**Figure 6.** Hermaphrodite flower induction in *M. sahyadrica* female genotype with 500 ppm AgNO<sub>3</sub> spray application. **a.** Induced hermaphrodite flower in *M. sahyadrica*. Notice on pedicel, a male bract typical to a male flowers as well as ovary typical to a female flower both exist in a hermaphrodite flower as a morphological identification key. **b.** Induced hermaphrodite flower in *M. sahyadrica* with normal stigma and anthers. Notice pollen-grains attached to fingertip.

inducing hermaphrodite flowers on female genotypes of *M. sahyadrica*, female homosexual hybrids (FHHs) can be generated. FHH is a hybrid progeny of two genetically female genotypes. FHHs generation was also attempted in *M. cochinchinensis*. FHHs being a hybrid of two genetically female plants, produced only female plants, whereas the normal hybrids segregated into male and female in an equal proportion<sup>8</sup>. Both inter-specific and intra-specific FHHs can be explored using *M. sahyadrica*, so as to combine the desirable characters of two female genotypes into a single genotype.

To strengthen propagation, innovative vegetative propagation approaches and tissue-culture can be used in the Sahyadri gourd.

*M. sahyadrica* is an important albeit lesser-known traditional, underutilized vegetable that requires focused research and development to mainstream it as a potential vegetable of immense nutritive value. Primarily, it needs transition from wild and semi-domesticated habitat into a domesticated habitat that matches the environs for its commercial utilization. Further, techniques like exploration, collection, evaluation, selection, inter and intra-specific hybridization, polyploidy breeding, FHHs, vegetative propagation and tissue culture can be employed to recover promising genotypes and mainstreaming of the Sahyadri gourd.

**Conflict of interest:** The authors declare that there is no conflict of interest.

1. Kuo, C. G., Schafleitner, R., Schreinemachers, P. and Wopereis, M. C. S., Vegetables and Climate Change: Pathways to Resilience. WorldVeg Publication No. 20-843, 2020; <https://worldveg.tind.io/record/73383?ln=en> (accessed on 26 July 2022).
2. Critical Ecosystem Partnership Fund, Biodiversity hotspots, 2022; <https://www.cepf.net/our-work/biodiversity-hotspots> (accessed on 26 July 2022).
3. Ramalhet, C., Gonçalves, B. M. F., Barbosa, F., Duarte, N. and Ferreira, M.-J. U., *Momordica balsamina*: phytochemistry and pharmacological potential of a gifted species. *Phytochem. Rev.*, 2022, **21**, 617–646; <https://doi.org/10.1007/s11101-022-09802-7>.
4. Kattukunnel, J. J. and Antony, V. T., *Momordica sahyadrica* sp. nov. (Cucurbitaceae), an endemic species of Western Ghats of India. *Nordic J. Bot.*, 2007, **24**, 539–542.
5. Bharathi, L. K. and John, K. J., Ethnobotany and nutritive value. In *Momordica genus in Asia – An Overview*, Springer, New Delhi, 2013; [https://doi.org/10.1007/978-81-322-1032-0\\_5](https://doi.org/10.1007/978-81-322-1032-0_5).

6. Joseph, J. K. and Antony, V. T., Ethnobotanical investigations in the genus *Momordica* L. in the southern Western Ghats of India. *Genet. Resour. Crop Evol.*, 2008, **55**, 713–721; <https://doi.org/10.1007/s10722-007-9279-5>.
7. Bharathi, L. K., Munshi, A. D., Chandrashekar, V. S., Behera, T. K., Das, A. B., John, K. J. and Vishalnath, Cytotaxonomical analysis of *Momordica* L. (Cucurbitaceae) species of Indian occurrence. *J. Genet.*, 2011, **90**, 21–30; <https://doi.org/10.1007/S12041-011-0026-5>.
8. Sanwal, S. K., Kozak, M., Kumar, S., Singh, B. and Deka, B. C., Yield improvement through female homosexual hybrids and sex genetics of sweet gourd (*Momordica cochinchinensis* Spreng.). *Acta Physiol. Plant.*, 2011, **33**, 1991–1996; <https://doi.org/10.1007/s11738-010-0693-5>.
9. Bharathi, L. K. and John, K. J., *Momordica* genus in Asia – An Overview, Springer, New Delhi, 2013; <https://doi.org/10.1007/978-81-322-1032-0>.
10. Indira Gandhi Krishi Vishwavidyalaya, Spine gourd. Indira Kokonda 1, 2022; <https://igkv.ac.in/> (accessed on 14 July 2022).
11. ICAR-Indian Institute of Horticultural Research, Vegetable varieties or hybrids, 2022; <https://www.iihr.res.in> (accessed on 14 July 2022).

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## Study of decadal variations in width and mangrove cover of the Thane Creek, Maharashtra, India, using remote sensing

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**The present study depicts decadal variations in the area, width and mangrove cover of Thane Creek, Maharashtra, India, using the remote sensing technique. The study is significant because the Creek has lush-green mangrove cover on its vast intertidal region and considerable urban developmental activities are occurring around it. Landsat datasets were used for different years from 1972 to 2014 and Sentinel 2A satellite data were used for the year 2020. To understand the variations in width from mouth to upstream, the Creek was divided into three zones, viz. mouth, middle and upstream. For mangrove cover estimation, supervised classification analysis was used for images from 2005 to 2014, while**

**object-based image classification analysis with multi-spectral resolution was used for images from 2020. From the results, it can be confirmed that there is an overall increase in the spatial extent of mangroves and a reduction in the width of Thane Creek. The study also shows that creek width had decreased by 1.15 km at the mouth and 0.08 km at the upstream end from 1972 to 2020, while mangrove cover had increased by 14.1 km<sup>2</sup> from 2005 to 2020 (15 years). The overall reduction in the area between the west and east banks of the Creek was around 15.3 km<sup>2</sup> from 1972 to 2020. This study shows that Thane Creek is rapidly narrowing at its northern end.**

**Keywords:** Creek, decadal variations, mangrove cover, mudflats, remote sensing.

CREEKS and estuaries are important coastal features as they play a crucial role in materials transport, groundwater recharge, nutrient cycling, controlling floods and sediment filtration, thus helping balance the ecological processes<sup>1</sup>. The intertidal regions of the creeks generally have a rich growth of mangroves along with mudflats that play a significant role in the nutrient enrichment of the creeks. The presence of mangroves in the creeks is important in the transport of organic matter and nutrients, thus providing breeding grounds for various marine organisms, including fishes.

Mumbai is one of the most populous metropolitan cities in Maharashtra, India. It is also called the financial capital of India and is one of the densest industrial hubs. Three creeks, viz. Thane, Gorai and Malad are found in the Mumbai coastal region. Among these three major creeks, Thane Creek has numerous drainage streams coming from Mumbai sub-urban areas. This Creek has a vast intertidal extent on both sides. It has been subjected to changes over a period of time due to anthropogenic activities on both the east and west banks. A study of the variations of mangrove cover is essential for planners. Remote sensing and GIS are the most suitable techniques to study and monitor coastal features.

Remote-sensing data give information on various components of the coastal environment, viz. mangrove density mapping, shoreline changes, tidal boundaries, brackish-water areas, suspended sediment dynamics, coastal currents, pollution, zonation of mangrove communities, etc. Only a few studies have been carried out to explain the variation in mangrove cover on the west coast of India. Mangrove cover in Thane Creek has been studied by several researchers using the remote sensing technique<sup>2-6</sup>. Ritesh *et al.*<sup>7</sup>, using satellite data, estimated the mangrove cover of three creeks, viz. Malad, Manori and Thane. They found that mangroves around the Thane and Manori creeks have increased from 50.7 to 57.6 km<sup>2</sup> and 8.4 to 25.2 km<sup>2</sup> respectively. However, there was a decrease in mangrove cover around Malad Creek from 13.3 to 9.7 km<sup>2</sup> from 1972 to 2016.

Using IRS P6 dataset, Abhyankar *et al.*<sup>8</sup> found that mangrove cover in the Mumbai region had decreased marginally from 50.5 km<sup>2</sup> in 2004 to 48.7 km<sup>2</sup> in 2013. Their study was

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