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Research Article

Participatory approach with stakeholder convergence for in-situ conservation and utilization of the *'Bedakam thengu'* coconut ecotype

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ABSTRACT

Coconut (*Cocos nucifera* L.) genetic diversity is largely conserved in farmers' fields as locally adapted ecotypes, with farmers' knowledge playing a key role in their identification and maintenance. Effective conservation of these resources requires a participatory, multi-stakeholder approach. *Bedakam thengu* is a farmer-preferred coconut ecotype widely grown in the Kasaragod district of Kerala, India, developed through long-term farmer selection from the West Coast Tall (WCT) population. It is valued for its superior adaptation to rainfed conditions and stable performance under low-input management. To systematically characterize, conserve, and promote this ecotype, ICAR-Central Plantation Crops Research Institute (ICAR-CPCRI), Kasaragod, implemented a participatory action research programme. Participatory studies validated its desirable agronomic traits. A major outcome was the formation of the *Bedakam Coconut Growers' Society*, a Farmer Producer Organization with over 2000 members, supported by the Kerala State Biodiversity Board and local governments. Trainings enabled production and distribution of quality seedlings, facilitating in situ conservation and wider adoption of this valuable coconut ecotype.

Key words: Coconut ecotypes, *Bedakam thengu*, participatory characterisation, *in-situ* conservation

Introduction

The foundation of sustained crop productivity in breeding programmes rests on the core pillars of conservation, characterization, and utilization of genetic resources. The coconut (*Cocos nucifera* L.), with its long history of domestication and human association, exemplifies this principle. Throughout its evolution under cultivation, distinct cultivars have emerged in specific geographical locations, often becoming known by their toponym's (Ashburner *et al*., 1997a; Ashburner *et al*., 1997b; Samsudeen *et al*., 2006). These regionally distinct populations, commonly classified into Afro-Indian, South East Asian, and Polynesian groups (Ramanatha Rao *et al*., 2005), represent ecotypes exhibiting continuous variation. A rich diversity of these varieties is maintained in farmers' fields, yet they remain underutilized by conventional coconut improvement research. *Ex situ* conservation in field gene banks presents significant challenges, including substantial spatial requirements, high labour costs, and the risk of genetic drift due to limited population sizes. *In situ* on-farm conservation offers a viable alternative to address these constraints. However, the long lifespan of the coconut palm demands a long-term commitment from farmers, making participatory approaches essential for creating sustainable conservation frameworks.

The genetic diversity held *in situ* offers immense potential for addressing cultivation challenges and providing new opportunities for growers. A comprehensive understanding, characterization, and identification of ecotypes with desirable traits are prerequisites for enabling stakeholders to leverage these resources for sustainable production and enhanced farmer income. The successful implementation of such interventions critically

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depends on the active participation and convergence of efforts from multiple stakeholders, including local farming communities. This paper elucidates a model framework of farmer-participatory, on-farm *in situ* conservation, developed and implemented on the '*Bedakam thengu*' ecotype from Kasaragod, Kerala, India, as a case study.

Materials and methods

The study was undertaken among the coconut holdings in Bedakam village, an undulating midland terrain. This eco-geographical area is situated 20 km from Kasaragod. Initial documentation of *Bedakam thengu* coconut ecotype was done as documentation of Indigenous Technical Knowledge (ITK) in coconut farming. During the interactions, the farmers highlighted *Bedakam thengu* as one of the most preferred variety cultivated in the region under sub-optimal management conditions. Subsequently, *Bedakam thengu* was assessed with the active participation of local coconut growers, which brought out its unique desirable traits. This was followed by detailed survey of the area and selection of 200 coconut palms of the ecotype from ten sites within the village for morphological characterization. Besides, the unique nature of the ecotype was studied using molecular tools. The ecotype was compared with the West Coast Tall (WCT), the predominant cultivar of coconut. Molecular characterization was done with 16 samples from *Bedakam thengu* and 17 samples from the WCT cultivar. Genetic diversity was assessed using a panel of 17 polymorphic coconut-specific simple sequence repeat (SSR) markers. A binary matrix of the scored allele data was utilized to evaluate genetic relationships. Similarity, among accessions was calculated based on Dice's coefficient (Dice, 1945; often attributed to Jaccard, 1908 for related binary similarity indices). Subsequent analysis, including the generation of a similarity matrix and the construction of a dendrogram via the unweighted pair group method with arithmetic mean (UPGMA), was performed using the NTSYS-pc software, version 2.0 (Rohlf, 1997).

Participatory interventions for *in situ* conservation and utilization of the ecotype was then implemented with the convergence of stakeholders including Farmer Producer Organisation, Local Self Governments, research institution, labour group and development agencies.

Results and discussion

The West Coast Tall (WCT) is the predominant cultivar of coconut cultivated along India's western coast. The migration of this cultivar from coastal to interior regions, followed by prolonged cultivation, adaptation to novel agro-ecological conditions, and human selection pressure, has likely driven the development of its contemporary genetic diversity. Farmer selection has led to the emergence of locally adapted populations, often distinguished from the generic WCT by specific toponyms. Documented examples of such ecotypes include *Kuttiadi, Jappanam, Komadan, Neduvarayan, Karinthengu, Chenthengu, Pathinettampatta, Arasampatti Tall,* and *Tiptur Tall* (Arulraj *et al*., 2002). Numerous additional locally recognized ecotypes are maintained by the farming communities across India's coconut-growing regions.

Kasaragod, the northernmost district of Kerala, India, borders the state of Karnataka. The district's topography is broadly categorized into three zones: a coastal lowland adjacent to the Arabian Sea, a midland region of undulating terrain, and an eastern highland. It encompasses five Agro-Ecological Units (AEUs) and is characterized by a warm, humid, tropical climate and major soil types including sandy, sandy loam, and laterite (CPCRI, 2002).

The '*Bedakam thengu*' coconut ecotype is predominantly cultivated within the Bedadka grama panchayat, located in the midland AEU 11

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(Northern Laterites). This unit, situated approximately 20 km inland from the Arabian Sea coast, features lateritic soils. Although not a traditional coconut-growing belt, coconut was introduced to this hinterland region approximately 200 years ago by migrant settlers. Continuous farmer selection and adaptation to the inland, hilly midland terrain are the proposed drivers for the evolution of this distinct ecotype, which is now cultivated alongside the West Coast Tall (WCT) cultivar.

This ecotype was formally identified as the predominant local cultivar through a focused group discussion (FGD) with farmers and researchers conducted by ICAR-Central Plantation Crops Research Institute (ICAR-CPCRI) during a project on indigenous knowledge documentation in coconut farming (CPCRI, 2002). Farmers attributed its popularity to a superior adaptation to rainfed conditions and improved performance under sub-optimal management practices compared to other tall cultivars.

Table 1. **Participatory analysis of performance of *Bedakam thengu* ecotype in comparison to WCT**

Sl. No.	Attributes considered for ranking	Score obtained (Scale:1 to 10)	
		Bedakam thengu	WCT
1	Availability of seedlings	8	8
2	Earliness in flowering	6	6
3	Less height of the palm	8	7
4	Nut productivity	9	7
5	Nut quality	8	7
6	Feasibility for mixed cropping	7	7
7	Susceptible to pests and diseases	7	7
8	Response to low input management	9	8
	Total score	**62**	**57**

Participatory assessment of the ecotype

After the initial documentation of *Bedakam thengu* farmer participatory assessment was carried out. Experiences of selected farmers in cultivating *Bedakam thengu* and WCT were analysed through scientist-farmer interaction sessions employing Participatory Rural Appraisal (PRA) techniques such as transect walk and matrix scoring. Apart from the traits already reported by farmers,other desirable qualities such as higher yield and lesser height of the palm compared to WCT were also attributed to *Bedakam thengu* (Table 1).

Morphological characterization

Farmer participatory assessment resulted in the identification of the Bedakam thengu with perceived desirable features. The ecotype endemic to the geographical area was further characterized for conservation and utilization. Vegetative, reproductive and fruit characters of the ecotype were recorded and found to be different from WCT cultivated in the area. The height of the palm was lesser than that of WCT and number of leaf scars in one meter length of trunk was more in the ecotype. Length of inflorescence, number of spikelets and number of female flowers were more in the case of Bedakam thengu resulting in the higher number of nuts. The shape of fruits of Bedakam thengu was ovoid compared to oblong shape of WCT. A comparative analysis of characters of the ecotype (n=171) as against WCT (n=53) are tabulated (Table 2, 3 and 4) below.

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Table 2. Comparison of vegetative characters of *Bedakam thengu* with WCT

Characters	*Bedakam thengu*	CV (%)	WCT	CV (%)	Significance of difference#
Age of the palm (years)	60		60		
Plant Height (cm)	1447	16.4	1536	11.9	**
Total no. of leaves	26.0	10.9	26.5	14.6	NS
Length of petiole (cm)	112.6	14.9	108.2	12.3	*
Length of leaf bearing portion (cm)	359.2	10.6	343.9	8.5	**
No. of leaflets	110.9	8.3	112.7	7.4	NS
Breadth of leaflets (cm)	5.4	15.8	5.6	12.8	*
Length of leaflets (cm)	113.9	14.8	115.9	8.44	NS
No. of leaf scars in 1m length	14.6	21.2	14.0	15.3	NS
Length of inter nodes (cm)	6.9	22.0	7.0	18.3	NS

**, **, represent statistical significance of difference at 5% and 1% , respectively whereas NS indicates non significance of difference.*

Table 3. Comparison of reproductive characters of *Bedakam thengu* with WCT

Characters	*Bedakam thengu*	CV (%)	WCT	CV (%)	Significance of difference#
Length of inflorescence (cm)	102.2	12.5	84.1	22.0	**
Length of stalk (cm)	43.5	14.8	42.3	21.6	NS
Length of spikelets (cm)	37.5	14.5	34.4	17.2	**
No. of spikelets/ inflorescence	33.3	18.5	33.9	13.1	NS
No. of female flowers/ inflorescence	22.2	39.3	19.4	44.8	*
No. of bunches/year	15.6	11.1	11.5	14.7	**
No. of bunches with button	2.5	27.5	1.7	33.4	**
No. of bunches with nuts	13.1	11.7	9.8	15.2	**
nut yield (per palm/year)	112.3	25.0	83.8	39.1	**

**, **, represent statistical significance of difference at 5% and 1% , respectively whereas NS indicates non significance of difference.*

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Table 4. Comparison of nut characters of *Bedakam thengu* with WCT

Characters	*Bedakam thengu*	CV (%)	WCT	CV (%)	Significance of difference[#]
Length of fruit (cm)	17.8	10.9	19.8	12.0	**
Breadth of fruit (cm)	15.1	11.5	14.7	14.0	NS
Weight of fruit (g)	897.2	17.5	856.5	29.7	NS
Thickness of husk (cm)	2.6	17.3	2.9	20.4	**
Weight of husked fruit (g)	486.6	15.8	482.9	37.9	NS
% husk to whole fr. Weight	45.3	13.0	44.0	17.7	NS
Thickness of kernel (cm)	1.3	12.2	1.3	10.5	NS
Weight of copra (g)	171.2	11.9	164.1	27.1	NS
Thickness of shell (cm)	0.48	15.4	0.44	19.0	**
Weight of shell (g)	124.6	14.3	129.5	26.9	NS
Nut cavity (ml)	141.3	20.8	154.6	46.1	NS

**, **, represent statistical significance of difference at 5% and 1% , respectively whereas NS indicates non significance of difference.*

From the morphological characterization, it was found that *Bedakam thengu* ecotype was distinct and different from WCT and possessed better yield attributes.

Molecular characterization

After the morphological characterization, *Bedakam thengu* ecotype was further subjected to molecular characterization. A total of 44 bands were produced by 17 primers. All the 17 primers showed 100% polymorphism. Cluster analysis was performed based on UPGMA using the software NTSYS. Two major clusters were obtained- *Bedakam thengu* and WCT formed distinct clusters, indicating the uniqueness of the former (Rajesh *et al.*, 2013).

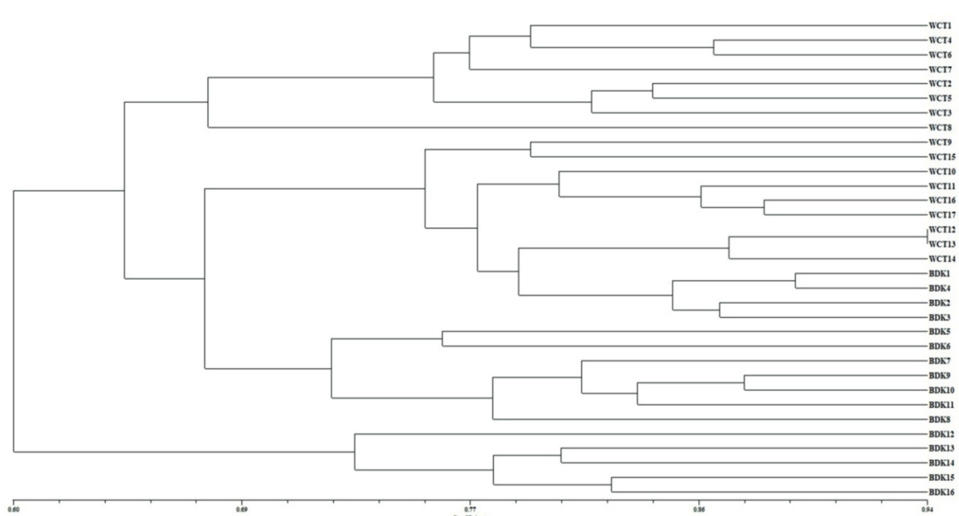

Fig. 1. UPGMA dendrogram based on Dice's coefficient showing two distinct clusters

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Conservation and utilization

Traditional approaches to coconut germplasm collection, characterization, and conservation have predominantly relied on *ex situ* field gene banks. While emerging techniques like cryopreservation offer promise, field gene banks remain the most practical and utilized repository for coconut genetic diversity, primarily due to the species' perennial nature and extended juvenile phase. A significant constraint of this method, however, is the protracted timeframe of 15–20 years required for reliable characterization of accessions.

Conversely, native *in situ* populations of these same accessions often persist in farmers' fields for over 50 years, reflecting the long economic lifespan of the coconut palm. Leveraging these established on-farm populations for characterization studies presents a strategic opportunity to drastically reduce this evaluation period to 2–3 years. This approach facilitates a paradigm shift in germplasm characterization, effectively merging the comprehensive merits of field gene banks with the efficiency and community engagement of participatory, on-farm conservation and utilization strategies.

Participatory characterization of coconut varieties was initially pioneered under the International Coconut Genetic Resources Network (COGENT) among farming communities across India and other member countries. This methodology aimed to document and evaluate varieties based on farmer perceptions and to identify key cultivation constraints (Thamban *et al.*, 2007). Building upon this foundation, the present initiative employed participatory methods for the on-farm conservation and utilization of the '*Bedakam thengu*' ecotype. However, this study extends the concept by transitioning from participatory identification to scientific characterization using standardized coconut descriptors following ecotype selection. The principal distinction between the two methods lies in their focus: the former was a community-based survey, while the present study constitutes an ecotype-based, scientific evaluation. Critically, both interventions are unified by their core principle: ensuring the active participation of coconut growers in the characterization of their genetic resources.

Farmer participatory interventions

A farmer-participatory characterization initiative for the '*Bedakam thengu*' ecotype, facilitated by ICAR-CPCRI, Kasaragod, successfully elucidated its unique and desirable agronomic traits. To translate these research findings into action, ICAR-CPCRI proactively engaged with local governance institutions. Findings were disseminated to the Bedadka Grama Panchayat to facilitate the development of conservation interventions under Kerala's decentralized planning programme. Furthermore, ICAR-CPCRI provided technical support to the Kasaragod District Panchayat and Karadka Block Panchayat to formulate projects and secure scheme-based funding to support the Grama Panchayat's initiatives. This multi-level stakeholder convergence has resulted in sustained financial support for the conservation of '*Bedakam thengu*' from all three tiers of local self-government (LSG) for the past two years, with the Agricultural Officer at Bedadka Krishibhavan (the local office of the State Department of Agriculture) serving as the implementing officer.

Concurrently, ICAR-CPCRI implemented awareness campaigns to educate local farmers on the importance of conserving this genetic resource. A pivotal outcome was the facilitation and registration of a Farmer Producers' Organization (FPO), the 'Bedakam Coconut Growers' Society' with over 2000 members. The primary objective of this FPO is to conserve and popularize the ecotype. A significant achievement of this society, undertaken with support from ICAR-CPCRI and Krishibhavan, is the initiative to register '*Bedakam thengu*' as a farmer-owned variety

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under the Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi.

To address the common constraint of limited availability of quality planting material, the project leveraged a decentralized, farmer-participatory approach for seedling production and marketing, a model previously validated by ICAR-CPCRI (Thamban and Samsudeen, 2022). Under this technology transfer programme, trainings were imparted in mother palm identification, seed nut collection, and nursery management practices, delivered through on-campus and off-campus programmes in collaboration with the FPO, LSGs, and Bedadka Krishibhavan. This support aimed to empower the 'Bedakam Coconut Growers' Society' to independently manage the production and marketing of authentic '*Bedakam thengu*' seedlings.

Convergence of stakeholders

The participatory conservation and utilization of the '*Bedakam thengu*' coconut ecotype largely resulted from a convergent, multi-stakeholder approach (Fig. 1). In addition to facilitating the establishment of a Farmer Producer Organization (FPO) and organizing capacity-building programs for farmers and stakeholders, ICAR-CPCRI provided technical support to the Biodiversity Management Committee (BMC) of Bedadka Grama Panchayat. This collaboration enabled the successful preparation and approval of a project proposal submitted to the Kerala State Biodiversity Board (KSBB), securing financial support for conservation efforts. Key activities included the systematic documentation of '*Bedakam thengu*' mother palms in farmers' fields and specialized training programs for coconut growers and local stakeholders.

Ward members across the Grama Panchayat facilitated the enrollment of local ecotype cultivators into the FPO. In addition, 12 members of the Karshika Karma Sena (KKS), supported by the Department of Agriculture through Krishibhavan, were trained in mother palm selection, seed nut collection, and nursery management. The FPO authorized a KKS team to operate a dedicated nursery at Pandikandam for producing *Bedakam thengu* seedlings, which are distributed to farmers to promote wider cultivation.

Participatory approaches are increasingly recognized for enhancing crop genetic improvement and leveraging genetic diversity to advance sustainable agriculture (Vernooy, 2003). As a result, numerous international and national agricultural research institutions and non-governmental organizations have integrated these methods into their programs, with documented successes across Asia, Africa, and Latin America. The identification of supportive policy and legal mechanisms is essential to maintaining the diversity-oriented benefits of participatory plant breeding (Ceccarelli and Grando, 2007).

The successful conservation and utilization of '*Bedakam thengu*' through participatory methods underscore the importance of developing conducive policy frameworks. This case highlights the need for integrated research and development interventions that promote participatory strategies for conserving and utilizing locally adapted coconut ecotypes.

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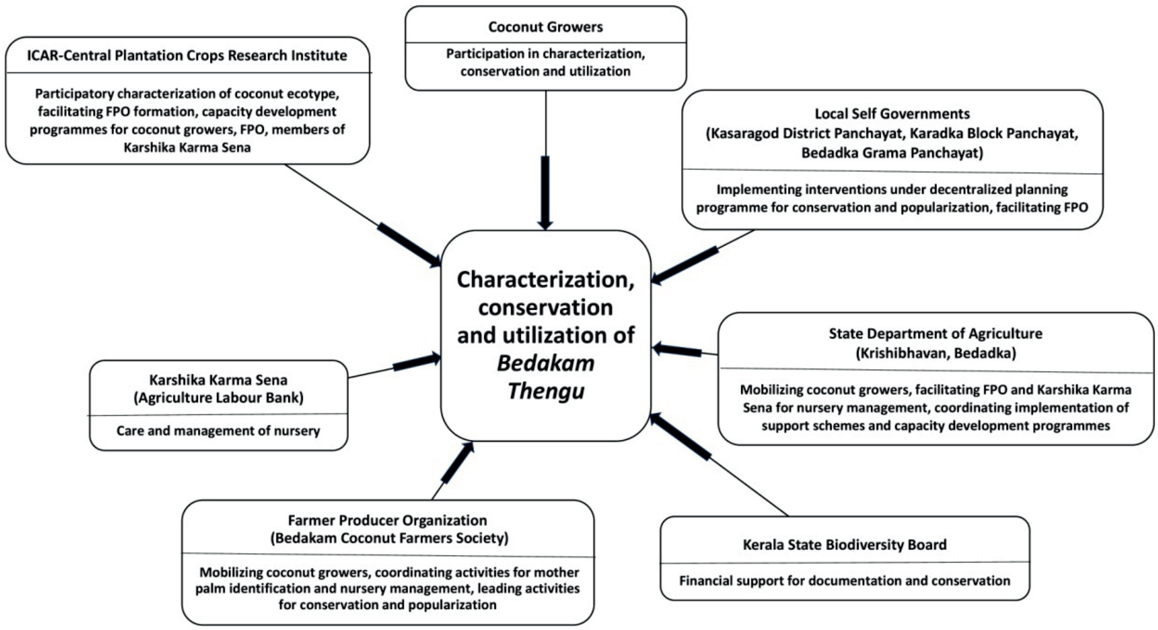

Fig 1. Convergence of stakeholders for conservation and utilization of *Bedakam thengu*

Key interventions for participatory characterization and conservation

The beneficial impact of implementing various interventions for the participatory on-farm conservation and utilization of '*Bedakam thengu'* are summarized below.

- Methodology evolved for the characterization, conservation and utilization of coconut ecotypes integrating participatory methods and scientific procedures
- Awareness created among farming community on the necessity of on-farm conservation of coconut ecotypes
- Empowerment of the Farmer Producer Organization to implement interventions for utilization of coconut ecotype
- Local Self Governments were sensitized to allocate financial resources under decentralized planning programme to promote conservation and utilization of coconut ecotypes
- Developed a framework to ensure convergence of stakeholders for conservation and utilization of coconut ecotypes
- Brought into focus the need to evolve a congenial policy environment to formulate development and research interventions for promoting participatory conservation and utilization of coconut ecotypes

Conclusion

Coconut, a perennial crop characterized by a prolonged juvenile phase and exclusive seed-based propagation, presents significant challenges for conventional *ex situ* germplasm conservation and characterization in field gene banks. These limitations arise primarily from the extensive time and resources required to establish and evaluate accessions. Consequently, participatory approaches that integrate interventions from multiple stakeholders are highly relevant for the *in situ* characterization, conservation, and utilization of coconut genetic diversity present in farmers' fields. Effectively

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mobilizing and engaging farmers in conservation initiatives is essential and should be incorporated into broader crop improvement strategies for coconut. Rather than isolated efforts, a convergent model involving diverse stakeholders including research institutions, local governments, farming communities, and agricultural extension services proves more effective for the conservation and sustainable use of locally adapted coconut ecotypes. The successful conservation and popularization of '*Bedakam thengu*', a promising coconut ecotype, through a coordinated multi-stakeholder initiative, serves as a compelling demonstration of the efficacy of such participatory approaches.

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