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RESEARCH PAPER

Transforming Tribal Livelihoods through Agri-Horti Interventions in Barren Lands of Goa

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ABSTRACT

The decision to leave land fallow is primarily influenced by factors such as lower farm profitability, undulating topography, and the migration of rural youth to urban areas. To demonstrate the potential of the agri-horti system in overcoming these challenges, ICAR-Central Coastal Agricultural Research Institute, Goa designed and implemented interventions in a community-owned farm of Gaondongrim village of Canacona Taluka in South Goa under the Scheduled Tribe Component (STC) programme. These interventions were: (i) rejuvenation of barren land through the planting of improved cashew varieties under the agri-horti system, (ii) improved nutrient and production technologies, (iii) effective utilization of interspace and available natural resources and (iv) value addition through the preparation of feni from cashew apples. Through repeated measures ANOVA and paired-t test, the impact of these interventions was assessed. Findings revealed that the employment generated at the farm significantly increased from 730 mandays per year (2017-18 – before interventions) to 1,697 mandays per year (2022-23 – after the interventions) and net returns also significantly improved by ₹ 4,31,377. This community-owned farm acts as a role model for rejuvenating barren land, creating a sustainable production system at the village level for generating substantial employment options, promoting crop diversification and improving the livelihoods of farmers.

HIGHLIGHTS

- Declining agricultural profitability is a key factor influencing the decision to leave land fallow.
- Successful agri-horti interventions in barren farmlands significantly enhanced on-farm employment generation and net returns for 33 scheduled tribe farm families.
- This demonstration farm is acting as a role model for rejuvenating barren lands and fostering sustainable rural employment and economic ventures.

Keywords: Barren land, repeated measures ANOVA, paired t-test, Cashew, Employment

The coastal ecosystem, including Goa, is already a challenging factor for crop production due to its undulating topography, barren land and poor soil fertility features that hinder cultivation practices (Verma *et al.* 2021). In Goa, during recent years, cultivable waste including fallow land and current fallow was on the rise and reached 68,926 hectares (Anonymous, 2020). Though the unemployment rate is higher in Goa, educated youth are less willing to take up agriculture which is leading to increased migration to urban areas, higher fallow land and slower adoption of improved agricultural technologies in the state. Tribal people, mostly residing in rural areas, have weaker economic status

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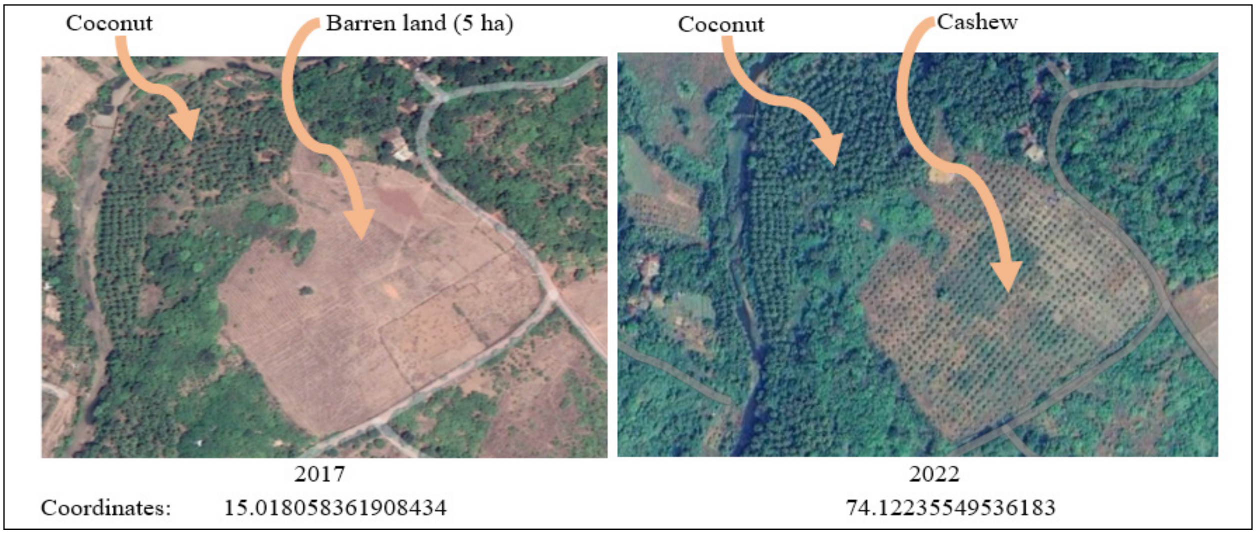
and require additional handholding support to adopt improved agricultural technologies.

Diversification of traditional agriculture into modern scientific systems helps to sustain the agricultural ecosystem and improve the farmers' livelihoods. Agri-horticulture system is one of the viable options as it provides seasonal income to the farm family and also improves soil fertility which leads to a sustainable production system (Gupta *et al.* 2022). Agri-horti-livestock-cum pisciculture along with rainwater harvesting uplifted the livelihood of Tribal farmers (Das *et al.* 2014). Saha *et al.* (2015) also reported that the adoption of either multi-storeyed agroforestry or silvi-horti-pastoral systems enriched poor farmers with healthier living environments through the conservation of natural resources. Further, there is also a scope for intercropping of tuber crops, cereals, vegetables, etc. in plantation crops which provides additional income besides reducing soil erosion (Monteiro *et al.* 2017; Kumar *et al.* 2020). Considering these scenarios, ICAR-Central Coastal Agricultural Research Institute (ICAR-CCARI), Old Goa designed and implemented suitable interventions to improve the livelihoods of tribal farmers in a community-owned farmland in Goa under the centrally sponsored Scheduled Tribe Component (STC). These interventions were aimed at bringing a sustainable solution to the prevailing problems such as lower productivity and returns, lack of viable employment opportunities at the village level, the problem of fallow land and lack of knowledge among farmers regarding value addition. This study attempts to measure the impact of these interventions on costs, returns, productivity and employment generation at the farm level.

METHODOLOGY

Under the STC programme, ICAR-CCARI, Goa, undertook interventions for improving farmers' livelihood since 2018-19 at the community-owned land in Ziltawadi village of Gaondongrim Panchayat, Canacona, Goa (15°01′05.3″N 74°07′20.4″E). The Institute facilitated the formation of the Ziltawadi Farmers' Self Help Group (SHG) of 33 farm families who collectively owned and farmed this 10-hectare farm. The average family size was four members. The study area is near the Arabian Sea and falls under the Western Coastal Plains and Ghats agro-climatic zone of India. The elevation is 29 m above mean sea level. The temperature ranged between 22 to 31°C with an average temperature of 26.3°C. The highest relative humidity (RH) was found in July (90.6%), while the lowest RH was noticed in December (63.2%). The mean annual precipitation was 2936 mm. Soil is shallow to medium deep, red lateritic with gravels. Satellite and camera images of the study area (before and after intervention) are shown in Fig. 1.

Before the intervention, out of the 10 hectares of farmland, only five hectares were under cultivation (coconut and banana) and the remaining area (5 ha) was barren land which was left fallow



Note: *Location coordinates: 15°01′05.3″N 74°07′20.4″E*

Fig. 1: Satellite images of the location: before & after interventions

for more than 20 years. During the first year of intervention (2018-19), in the barren land, 1200 cashew grafts of improved varieties were planted to transform the barren land into an agri-horti system. Irrigation facilities were created on the farm. Banana intercrop was intensified in the coconut plantation and integrated nutrient management was undertaken in the existing coconut-based planting system for improving productivity levels. Further, the interspace available in the newly planted cashew orchard was effectively utilized through intercropping of finger millet, tuber crops, chilli, maize, brinjal and okra.

Data on various aspects of farming such as family labour, cost of production, yield and gross returns were collected from the 33 farm families using a pre-tested structured schedule.

Considering the gestation period of perennial crops like cashewnut, the repeated measures for on-farm employment generation and net income were collected for the baseline year (2017-18) and after the interventions (2021-22 & 2022-23). Labour productivity was calculated by dividing the gross and net returns by the mandays employed. The paired t-test was used to estimate the impact of the interventions on net returns and employment generated at the farm family level. To compare the means of the two paired sets of data, before and after the interventions, the paired t-test statistic was computed using the following formula:

$$t = \frac{m}{s/\sqrt{n}} \qquad \ldots(1)$$

In this case, m is the mean value of the difference (d) and s is the standard deviation of the difference, whereas n is the size of d, in this case, it was 33. The degrees of freedom (df) used in this test are: $df = n - 1$, 32 in this case.

As data were collected from three different periods (2017-18, 2021-22 & 2022-23), one-way repeated measures ANOVA (Table 1) was also employed to ascertain the statistical significance of changes in on-farm employment generation and net income of 33 farm families.

RESULTS AND DISCUSSION

Impact on employment generation at the farm level

Comparison of employment generated at the farm before and after interventions (2022-23) showed a significant difference as measured by paired-t test (Table 2). During 2017-18 (before the intervention), a total of 730 mandays (657 for coconut and 73 for banana) were generated. However, after the interventions (2022-23), employment generated rose by 2.3 times to 1697 mandays per year. After the interventions, employment opportunities were generated for the year-round engagement of four family members regularly (1460 mandays) and additional family labourers (237 mandays) were also involved in performing seasonal operations such as cashew harvesting, feni distillation, *ragi* transplanting, harvesting and threshing, planting and harvesting of tuber crops. Thus, a total of 1,697 mandays (1,022 for coconut, 372 for cashewnut, 151 for banana, 122 for *ragi* and 30 for tuber crop) employment was generated, which was an increase of 967 mandays compared to 2017-18. Bringing an additional 5 hectares area under cultivation and crop diversification and intensification (intercropping of *ragi* and tuber crops under cashew) led to increased agricultural operations which provided higher employment opportunities at the farm level. Hong *et al.* (2019) also pointed out that intercropping required more labourers compared to sole cropping.

Table 1: One-way repeated measures ANOVA framework

	Independent variable (year):		
Particulars	**2017-18 (period 1)**	**2021-22 (period 2)**	**2022-23 (period 3)**
Measure variables:	• On-farm employment generation • Net income	• On-farm employment generation • Net income	• On-farm employment generation • Net income
Data were collected from the same 33 farm families	33 farm families	33 farm families	33 farm families

Table 2: Impact of interventions on employment generation and farm income (community-owned farm of 10 ha) and paired-t test results

Sl. No.	Particulars	Details	Employment generated (No. of FL days/year)	Cost of FL (₹)	CoC other than FL (₹)	CoC (₹)	Yield	Gross returns (₹)	FL income (₹)	Net returns (₹) & t statistics
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7) (5+6)**	**(8)**	**(9)**	**(10) (9-6)**	**(11) (9-7)**
(I) Before interventions (2017-18)										
(a)	Coconut	803 plants	657	2,46,375	24,000	2,70,375	7,005 nuts	1,05,000	81,000	-1,65,375
(b)	Banana	409 plants	73	27,375	2,500	29,875	340 bunches	51,000	48,500	21,125
Total (I)			730[@]	2,73,750	26,500	3,00,250	—	1,56,000	1,29,500	-1,44,250
(II) After interventions (2022-23)										
(a)	Coconut	808 plants	1022	3,83,250	41,275	4,24,525	23,990 nuts	4,80,000	4,38,725	55,475
(b)	Banana	906 plants	151	56,625	5,375	62,000	550 bunches	1,10,000	1,04,625	48,000
(c)	Cashewnut	5 ha (1,208 plants)	372	1,39,500	39,758	1,79,258	1.3 tonne cashew & 350 L feni	2,52,000	1,06,800	72,742
(d)	*Ragi*	Intercrop	122	45,750	3,325	49,075	15 q	60,000	56,675	10,925
(e)	Tuber crops	Intercrop	30	11,250	1,265	12,515	25 q	112,500	1,11,235	99,985
Total (II)			**1,697[∂]**	**6,36,375**	**90,998**	**7,27,373**	—	**10,14,500**	**8,18,060**	**2,87,127**
Impact of interventions (II – I)			**967*** (t stat = 72.26)**	**3,62,625**	**64,498**	**4,27,123**	—	**8,58,500**	**6,88,560**	**4,31,377*** (t stat = 55.83)**

Note: *FL: Family labour; CoC: cost of cultivation; [@]Four family members working on a rotation basis (1/2 day) under coconut and banana plantation for 365 days; [∂]Four family members working whole day in the farm regularly and additional family members employed for seasonal operations (cashew harvesting, feni distillation, ragi transplanting, harvesting and threshing, planting and harvesting of tuber crops); ***Results of the paired t-Test indicated significant differences (at 1% level of significance).*

Impact on farm production and income

For reducing the migration of farm labourers to urban areas, a mere increase in employment generated at the farm level is not sufficient, an increase in net returns is also essential. The gross returns earned before the intervention were ₹ 1,56,000 from coconut (₹ 1,05,000) and banana (₹ 51,000) (Table 2). The total cost of cultivation before the intervention was ₹ 3,00,250 which included the cost of family labour to the tune of ₹ 2,73,750 (₹ 2,46,375 for coconut and ₹ 27,375 for banana) and other costs (₹ 26,500). The family labour income (excluding the cost of family labour) was ₹ 81,000 during 2017-18. However, if we account for the cost of family labour then the net returns were negative (₹ -1,44,250) before the interventions. Though the farm used to provide regular employment to four family members for half a day throughout the year, the negative net returns from the farm indicated that it was not sustainable in the long run. After the interventions (2022-23), both net returns and family labour income were positive and increased significantly as indicated by the paired-t test. The family labour income increased from ₹ 1,29,500 to ₹ 8,18,060 (an increase of ₹ 6,88,560) and the net returns from ₹ -1,44,250 to ₹ 2,87,127 (an increase of ₹ 4,31,377) after the interventions.

After the interventions, both the production and productivity of the farm improved. Further, an additional area of five hectares (barren land which was left fallow) was brought under cashew cultivation (1,200 grafts of improved cashew varieties). Though the cashew crop is yet to reach full yield potential, it was providing substantial income to the farmers with the production of 1.3 tonnes of raw cashew nuts and 350 litres of feni produced from the cashew apples. The total gross return from cashew was ₹ 2,52,000. Besides, interspace in the cashew field was effectively

Table 3: Results of One-Way Repeated Measures ANOVA for on-farm employment generation and net income

Source	Degrees of freedom	Sum of Square	Mean Square	F Statistic (df_1, df_2)	P-value
On-farm employment generation (per family)					
Between years	2	18652.11	9326.06	5294.38 (2,64)	<0.001
Between farm families	32	1037.08	32.41	18.40 (32,64)	<0.001
Error	64	112.74	1.76		
Total	98	19801.93	202.06		
Net Income (per family)					
Between years	2	3154513879	1577256940	2607.05 (2,64)	<0.001
Between farm families	32	48613455	1519170	2.51 (32,64)	<0.001
Error	64	38719730	604996		
Total	98	3241847064	33080072		

utilized through the cultivation of *ragi* and tuber crops which provided a cumulative gross return of ₹ 1,72,500. Improved production technologies were employed in the coconut-based farming system which led to the annual production of 24,000 coconuts from the earlier level of 7,000 nuts (243% increase). The gross returns from coconut increased from ₹ 1,05,000 to ₹ 4,80,000. The banana crop was intensified after the interventions, from the earlier 409 plants to 906 plants which provided a gross return of ₹ 1,1,000 from the earlier level of ₹ 51,000.

Repeated measures ANOVA results for employment and income

The Repeated Measures ANOVA test (Table 3) indicated that there is a significant difference in the on-farm employment generated per farm family over the three time periods, F(1.32, 42.39) = 5294.38, p <0.001, with an annual mean per farm family of 22.1 mandays for 2017-18, 51.01 mandays for 2021-22 and 51.42 mandays for 2022-23. Mauchly's test of sphericity indicated that the assumption of sphericity had been violated, $\chi^2(2) = 22.103$, p <0.001, and therefore a Greenhouse-Geisser correlation was used ($\varepsilon = .662$). The post-hoc paired t-test test using a Bonferroni corrected $\alpha = .017$ indicated that the means of the following pairs are significantly different: period 2 - period 1, period 3 - period 1.

For the net income per farm family, the Repeated Measures ANOVA test indicated that there was a significant difference in the net income over the three time periods, F(1.03, 33) = 2607.05, p <0.001, with a mean of -4371.21 for period 1, 6067.19 for period 2, 8700.82 for period 3. The post-hoc paired t-test test using a Bonferroni corrected α = .017 indicated that the means of all the pairs were significantly different: period 2 - period 1, period 3 - period 1 and period 3 - period 2.

The impact of technological interventions on improvement in labour productivity can be ascertained from the gross returns per manday and net returns per manday. Both gross returns per manday and net returns per manday improved after the interventions: The gross returns per manday increased to ₹ 598 from the earlier level of ₹ 214 with an improvement of 179% and the net returns per manday increased to ₹ 169 registering a growth of 186%. This shows the impact of technological interventions on improving labour productivity apart from increasing the employment generation on the farm.

Due to the interventions, besides the additional net income of ₹ 3,44,467, increased crop diversification, intensification and effective utilization of barren land were achieved. These advantages could be attributed to the efficient utilization of natural resources and effective soil conservation by intercrops as well as cashewnut. Earlier studies on the agri-silvi-horti system also reported that this system was the most beneficial farming system as compared to sole cropping (Kaushik *et al.* 2014). Ramteke *et al.* (2022) also reported that intercropping of tuber crops with cashew significantly improved the production efficiency and benefit-cost ratio compared with sole cashew due to higher gross return, net return and relative economic efficiency.

CONCLUSION

To overcome the challenges of declining farm profitability and increasing fallow land in Goa, appropriate agri-horti interventions were designed and implemented by ICAR-CCARI, Goa in a community-owned farm by 33 schedule tribe families at Gaondongrim village of Canacona Taluka, Goa. Net income and on-farm employment generation were analysed using repeated measures ANOVA and paired-t test. Findings indicated that interventions have not just rejuvenated the barren land successfully, but also generated employment opportunities at the farm itself, improved labour productivity and promoted crop diversification and intensification. These interventions also led to a significant increase in the net farm returns. Due to this, the farm is acting as a model unit for demonstrating these impacts on sustainability and improvements in the livelihood to villagers, researchers, developmental organizations and policymakers. There is a need to replicate similar interventions to attract and retain youth in agriculture through profitable and sustainable agricultural ventures in rural areas.

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