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Tribal rehabilitation and its impacts on land use changes, food security and sustainable livelihoods: a case study in South India

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ABSTRACT

Millions of tribals live in forests or adjacent protected areas and their food security and livelihoods depend on resources from the forests. Reportedly, about 40 to 60% of annual earnings of tribals, especially tribal women, is from collection and selling of forest produce. However, the idea of protecting biodiversity resulted in removal of people from forests and India was not an exception. This resulted in rehabilitation programmes as tribals were relocated to villages. The research sought to investigate the impacts of tribal rehabilitation on land use, food security and sustainable livelihoods in Rangayana Koppalu village in Karnataka, South India. In this paper, we developed a conceptual framework to determine the impacts of land use change on food security and livelihoods. To elicit information, 150 participants were selected through convenience sampling. We conducted PRA, besides in-depth interviews, survey interviews and focus group discussions to collect data. Results indicated food insecurity and unsustainable livelihoods with index scores of 10.03 and 0.27 respectively. The tribal rehabilitation programme had adverse impacts in the village. Policies on afforestation to consider undertaking a social cost benefit analysis of the rehabilitation process before implementation. Policies should provide for multi-stakeholder consultations before implementation of the tribal rehabilitation programmes.

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1. Introduction

According to Kothari et al. (1995), tribal communities historically resided in the forest, suggesting that there are still millions of people who live inside or close to designated forests and rely on forest resources for their food security and livelihoods. The 2011 census estimated that there are 104.3 million Scheduled Tribes (ST) in India, 94.1 million of whom reside in outlying rural areas. It is estimated that 8.6% of India's population is comprised of tribal people. According to statistics, India's total and rural tribal populations were around 125 million and 112 million, respectively, in 2020 (Haque et al., 2020). Over 50% of the tribal people in India live in forests and rely on the land and natural resources of the forest for their subsistence. In addition, gathering and selling forest products accounts for roughly 40 to 60 percent of tribal members' annual income, particularly tribal women (GoI, 2019). However, due to numerous development initiatives, tribal rehabilitation required the relocation of these tribal groups from the forests and their resettlement in a village. According to Fanari (2019), biodiversity conservation efforts around the world have forced evictions and resettlement of people living near forests. In fact, it is argued that these expanding international measures for environmental protection are frequently carried out at the expense of communities living in and around significant biodiversity spots. Certainly, India was not an exception to this as it implemented tribal rehabilitation programmes countrywide, necessitated by the demand to increase national protected forest area, besides various afforestation and infrastructure development programmes (Figure 1).

After these evictions forests were not abandoned but managed using the forest policies, and because

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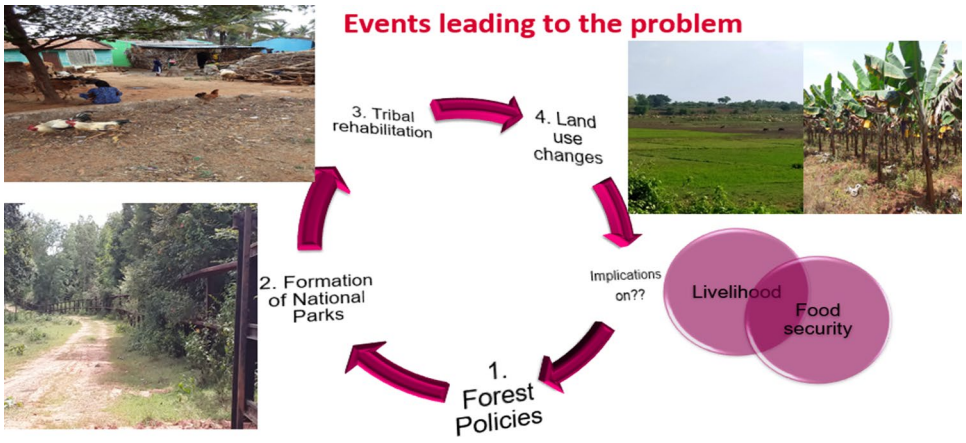

Figure 1. Events leading to food insecurity and poor livelihood: *Source:* Authors; PRA sessions (2022).

of these forest policies there has been signs of forest growth as more land has been converted or transformed into protected areas including the formation of national wildlife parks. The analysis conducted by the researchers reviewed that from 1987 and for the past 7 years from 2015 to 2021, the forest cover in square kilometres has been increasing. This also includes biodiversity as Nagarhole National Park is now a protected area with a very high population of tigers and prey near to their potential carrying capacity including other natural biodiversity. In 1987, a total forest and tress cover of 23.81% of the geographical area. In 2021, the total forest and tree cover stands at 24.62%.

Historically, forest policies demanding for more forest land were instrumental in India. For instance, the earliest National Forest Policy of 1952 called for 33% forest cover (Myers et al., 2022), which led to major land use change as the forest policies demanded conversion of village-forest into protected areas and rehabilitation of the people outside the forest. In the regional context of Karnataka state, this led to the formation of Nagarhole National Park in Mysore District and the rehabilitation of the tribal people (Adams & Mulligan, 2003) in Rangayana Koppalu. Even though the tribal people were custodians of the forest, according to Prakash (2016), the tribes were forest's guardians, as they lived in harmony with nature preserving and utilising the forest's resources. Thus, while forest laws and policies were instrumental in the formation of protected areas, they also resulted in the eviction of indigenous communities from the forested areas.

It was worth to note that despite living in harmony, people population expansion in the natural forests resulted in an increase in the demand for natural resource usage (land, soil, water, forest), leading to excessive use and ecosystem deterioration, Nagarhole National Park was not exceptional. The forest dwellers caused harm to the forest by hunting animals, deforestation or excessive timber harvesting, forest fires, land degradation, water pollution etc. The rate of natural resource regeneration has been outpaced by current levels of use including threatening the livelihoods and food security of these tribal people who relied on natural resources as there was over exploitation without replenishment. Therefore, the indigenous people were seen as poachers, encroachers and responsible for the decline of forest biodiversity and the authorities consider relocation and displacement from their only livelihood strategies to save the environment (Dowie, 2009).

India joined the list of nations in the world that have passed laws and policies to manage, protect and conserve forested forests. The Indian Forest Act of 1927, which was passed, outlines the laws controlling forests, the movement of forest products, and the levies of timber and other forest products. Colonial law, which realised the value of maintaining forests to conserve natural resources, had an influence on and guided the construction of protected forest areas (Mathews, 2005). This concept of forest conservation encouraged the conceptual separation of humans from nature and the isolation of nature from its cultural values (Adams & Mulligan, 2003), which resulted in the expulsion and rehabilitation of numerous humans from the forest areas. According to this theory, relocation and displacement from their sole source of support would be necessary to protect the environment because indigenous people are seen as poachers, encroachers and responsible in the degradation of forest biodiversity (Dowie, 2009). Similarly, the Forest Act of 1927 contains a clause on reserved forest that prevents the gaining of forest

Figure 2. Interlinkage of the Sustainable Development Goals to SDG 2, *Source:* Authors (2022).

rights and forces indigenous people to leave their ancestral homes. Therefore, according to Sophie et al. (2015), tribal rehabilitation caused changes in farming methods and land usage across Indian states, changing from village-forest to protected.

In this regard, we examine the impacts of the tribal rehabilitation for forest protection in the Rangayana Koppalu village in Karnataka, South India. Accordingly, the research sought to investigate the impacts of rehabilitation programmes on the land use change, thereby the food security and livelihood in the rehabilitated village.

2. Literature review

The relocation of forest dwellers to rehabilitation villages could have destabilised farming and livelihood activities of the affected people. The programme led to land use changes in forest and in rehabilitated village leading to food insecurity. For a community to be considered food secure, all four food dimensions must be provided. Programmes and policies should consider needs for all food security dimensions, according to Childress et al. (2022). According to the United Nations (2008), food security is the assurance of food accessibility, utilisation, stability, as well as the production of enough food to meet the population's needs. In 2015, Sustainable Development Goals (SDGs) were developed and adopted to enforce the above definition, where SDG2 aims to end hunger, achieve food security, improve nutrition and promote sustainable agriculture, overlaps with other SDGs' indicators, particularly SDGs 1, 3, 4, 5, 6, 8, 12, 13, 14 and 15 (FAO, 2017). Viswanathan et al. (2020) concurred that in fighting hunger several Sustainable Development Goals (SDGs) and subcomponents are achieved, mainly, SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (good health and well-being), SDG4 (quality education), SDG5 (gender equality), SDG 6 (clean water and sanitation), SDG 8 (decent work and economic growth), SDG 12 (responsible consumption and production), SDG 13 (climate action) SDG 14 (Life below water) and SDG 15 (life on land), therefore, the researchers illustrated the linkage in Figure 2 below.

The rehabilitation could have affected the farming system of the villagers and subsequently affecting the achievement of the above overlapping SDGs. The fulfilment of these SDGs could be positively or negatively impacted by several issues, including rehabilitation, where major infrastructure investment and development will be required, and land use, where engagement on policy implementation will be crucial. According to Rathee (2014), land use change and rehabilitation have had a number of effects in India, including converting village forests into protected areas and transforming small-scale farming into intensive agriculture. The study also made clear that the community's agro-economy, which is its main source of income, is affected by the loss of agricultural land. This is worsened by lack of land titles and land rights as their inherited grandparents' land is repossessed by the government for other uses. According to Reddy et al. (2020), the lack of land titles and land rights for indigenous populations has had a detrimental effect on household food security, productivity and agricultural investment. According to Desta et al. (2021), subsistence farming also lowers manpower and crop cultivation costs, reduces water loss from the soil, improves infiltration rates, and give enough yield, these are benefits needed in rural farming. Although the rehabilitation

was an introduced development, it had a significant negative impact on the social, economic and agricultural activities of the tribal people, which caused resistance and prevented the new village's living standards from improving. Plans that are implemented without adequate impacted parties' input or involvement will typically fail. According to Scott (2020), state officials always reasoned that once a peasant was given a farming land and a house, he or she would suddenly want to become wealthy, organise his or her household into an efficient workforce, and pursue agriculture or development. Instead, Scott came to the conclusion that the reality was different, the scheme will fail and that it is important to remember that society has the power to alter, resist, circumvent and even destroy the classifications that are imposed upon it, in addition to the ability of governmental simplifications to change society as a whole.

According to Chambers and Conway (1991), a livelihood consists of the abilities, possessions and activities needed for a means of sustenance. The rehabilitation plan may have disrupted sources of income, increased vulnerability, stress and shocks, and created difficulty coping. According to Lasgorceix and Kothari (2009), the food security and sustenance of the indigenous people were jeopardised, which resulted in social, economic and environmental trauma. According to FAO (2014), forests play a vital part in sustaining the livelihoods of those that live nearby, with forest products accounting for about 22% of the local economy. Several villages cherish the forest's holy areas, which they dedicate to regional deities or Gods (Forest Rights Act, 2006). The woodland also has religious significance for the Tribe. According to Munshi (2012), the Tribal people used to farm in forests and harvest non-timber forest products (NTFP) including nectar, foliage and wildflowers to produce between 50–80% of their food. They exchange or sell extra forest resources to help their local communities. The tribes rely on their land to support their way of living because the humid, fertile soil feeds their crops and the native vegetation that their animals eat. Therefore, while protecting the forest is important, displacing indigenous peoples is not. The state might have protected tribal land rights and collaborated with the tribal members to strengthen neighbourhood conservation efforts using the provisions of The Indian Forest Act (1927), which would have prevented the disastrous effects of the rehabilitation. Debie et al. (2022) suggested that it is essential to combine both traditional and recently established fundamental land management practices to avoid different kinds of conflicts, land degradation and take steps to promote livelihood improvement. As a result, timely compensation was required to rebuild their livelihood. Reddy (2018) pointed out that giving compensation to individuals who are displaced and creating job and income possibilities to support them are common foundations for restoring livelihoods in involuntary relocation. In this case, consultation with forest dwellers before rehabilitation was very important as there could have different needs or different compensation requirements in the introduced development or rehabilitation scheme. A family's subsistence needs might not be satisfied by something that satisfies another's, particularly when it comes to compensation and land. Each resident family's size and the number of individuals in the family who are physically capable should determine how the land is divided among them. All cropland returns to common land following the main season crop's harvest, allowing any family to graze their animals, harvest food and even grow rapidly maturing dry season crops (Scott, 2020). Therefore, the state introduced rehabilitation could have caused more harm, implications and failed despite being a scheme to improve human conditions and biodiversity.

As in any other regions in India, the tribal rehabilitation programmes could have caused major changes in land use thereby affecting food security and livelihood in Rnagayana Koppalu village as well. In this regard, the objective of this paper is to investigate the impact of rehabilitation on the land use change, thereby the food security due to changing farming systems, and the livelihood in the rehabilitated village.

3. Methods and data

3.1. Design and sample

An ethical clearance was obtained to conduct a research (appendix 1), where a descriptive research design was applied to examine how the tribal rehabilitation programme has impacted in the village. Used convenience sampling technique to select 150 individual participants. We undertook a participatory rural appraisal (PRA) involving 60 villagers/farmers including the eight member village leadership committee, to ensure accuracy, avoid bias, to find points of consensus or contradiction, to facilitate mutual learning, to integrate knowledge and to reach the

reliability and validity desired. To achieve this, we adopted the approaches, such as resources sketch mapping, seasonal calendars, historical trends, transect walks and direct observations, and the preparation of problem and solution trees. The data collected was based on qualitative information on land use changes and rehabilitation incidents, and quantitative information on food security and livelihood. Standard data collection forms were adopted based on WFP, USAID and FAO dataset to collect food security information. Livelihood data pertained to the five forms of capital, viz., financial, human, social, physical and natural capital; whilst food security covered the four critical dimensions of: (a) food availability, (b) food utilisation, (c) food accessibility and (d) food stability. Qualitative data on tribal rehabilitation and land use were collected through in-depth key informant interviews (involving 20 elderly, 30 government officials) and 6 focus group discussions (each having 8 villagers/farmers and 2 key informants), whilst quantitative survey (involving 150 villagers/farmers) was conducted to collect data on food security and livelihood.

3.2. Measurements of sustainability of livelihood and food security

The livelihood and food security conditions in the rehabilitated settlement have reached extremes and are affecting the social, economic and environmental requirements of both humans and nature. These extremes are led by land use changes induced by both anthropogenic activities, and by the implementation and reinforcement of the forest Acts and policies as forest protected areas were formed and subsequently led to the eviction and rehabilitation of the tribal people. Therefore, there was a need to measure the livelihood status index and food security index of the village and recommend remedial actions to the villagers, policy makers and stakeholders. We used the WFP (2008, 2016), FAO. (2013) and USAID (2008) indices to measure food security and livelihood status.

Mutea et al. (2019) revealed that the mostly used food security indices by WFP, FAO and USAID to assess household food security are: household dietary diversity score (HDDS), food consumption score (FCS), coping strategies index (CSI), months of adequate household food provisioning (MAHFP) and household food insecurity access scale (HFIAS). Pérez-Escamilla and Segall-Corrêa (2008) added household income and expenditure surveys (HIES) and others. Therefore, in this study the above six food security indices were applied to measure household food security index.

The formula used in Mutea et al. (2019) to calculate the overall Food security index (FSI) was used to assess whether all dimensions of food security correlated well.

$$\mathrm{xFSIn} = (\mathrm{zHDDSn} + \mathrm{zFCSn} + \mathrm{zMAHFPn} + (-\mathrm{zCSIn}) + (-\mathrm{zHFIASn})$$

where: xFSIn is the composite Food Security Index of the village; zHDDSn is the HDDS Z-score; zFCSnis the FCS Z-score; zMAHFPn is the MAHFP Z-score; zCSIn is the CSI Z-score and zHFIASn is the HFIAS Z-score. In this formula, higher scores imply higher food security.

According to WFP (2008, 2016), FAO. (2013) and USAID (2008) standards, the thresholds that are applied for composite FSI: a score of 0–21 indicates poor food security, a score of 21.5–35 indicates borderline food security and a score greater than 35 is considered an acceptable food security level.

Livelihood comprises the utilisation of social-economic capabilities, financial, human, social, natural and physical capitals assets and activities required for a means of living (FAO, 2013; Sharma, 2017; USAID, 2008; WFP, 2008, 2016). In this study, we calculated the Livelihood Status Index (LSI) of the village through computation of the asset status indices based on WFP, FAO and the USAID formulas. Theses formulas were also used by Islam et al. (2008) and Ahmed et al. (2011). Viswanathan (2008) also used the livelihood status index with a scale 0 –1 in a study on smallholder rubber farming systems in India and Thailand. The thresholds for composite Livelihood Status Index are: $0 \le \mathrm{LSI} < 0.40$ Low, $0.40 \le \mathrm{LSI} < 0.70$ Medium and $0.70 \le \mathrm{LSI} \le 1$ High or alternatively percentages can be used as follows $0 \le \mathrm{LSI} < 40\%$ Low, $0.40\% \le \mathrm{LSI} < 0.70\%$ Medium and $70\% \le \mathrm{LSI} \le 100\%$ High (Pal et al., 2015; Rodrigo-Ilarri et al., 2020). Viswanathan (2008) categorised the Livelihood Status Index as highly sustainable if its overall score ranges from 0.67 to 1; moderately sustainable if the value ranges from 0.34 to 0.66; and unsustainable if the value falls between 0 and 0.33. The Status Index score of each was calculated by using the following formula:

Status Index score = Sum of (*wi* multiple *fi*) divide by ***n***, where, wi = Weight, fi = No. of Respondents, n = Total Respondents (150*7*4) = 4200

$$\text{Therefore, } \mathbf{LSI} = \frac{(\mathbf{SSI\ score} + \mathbf{ESI\ score} + \mathbf{HIS\ score} + \mathbf{PSI\ score} + \mathbf{NSI\ score})}{(\mathbf{Number\ of\ SI\ scores})}$$

4. Results and discussion

4.1. General characteristics of resettlements areas

The research was carried out in Rangayana Koppalu village, it is a rural rehabilitation community situated some 10kms from Hunsur the nearest town, 40kms from Mysuru, district capital, 185kms from state capital Bengaluru in Karnataka state and global location of Karnataka state is 12°14′ N, 76°21′ E. (12.236305, 76.355244). The village has 120 families with a total population of 473 people and 130 houses across 5 tarred lanes. The gender ratio of the village is two women amongst every six men, which is equivalent to (1:3). The resettled site covers 30.6636 ha in total, whilst in the forest, which is 20kms away, the tribal used to utilise 152.3888 ha for both housing and farming including opportunity to do shift cultivation. However, geographically, there is very fertile red soil around the village and there is a lake nearby which can be used for irrigation of agricultural crops. The village is surrounded by farmlands, which grow maize, ginger, turmeric, bananas, coconut trees and other minor horticultural crops. The main livestock found in the village are cattle, sheep, goats, chickens and dogs. Villagers are not employed throughout the year resulting lack of enough food and income for satisfying the basic needs of a family, they work in the surrounding farms as part-time casual wage labourer. On infrastructure, the government provided the villagers with electricity, water, tarred good roads, a school up to standard five, however no other essential facilities like clinic, shops, market places except in nearby villages.

A pilot survey was carried out in the month of April 2022, participatory rural appraisal (PRA) was used to gather initial data through resource mapping, seasonal calendar, problem tree, transect walk, participatory observations and interaction. A participatory rural appraisal resulted in the development of a seasonal calendar for the village reflecting climatic conditions, phenomena and timing over a 1-year period, including the soil profile of the soil condition in the village, as shown in Figure 3 and in Figure 4, respectively. For this research, it was crucial to understand the soil composition in the village fields using soil profiling. In agriculture, the environment, land use and the adaptation and mitigation of climate change, soil is essential. The composition of the soil was found to consist of 45–49% minerals, 25–30% water, 25–30% air and 1–5% organic materials.

The soil composition profiling was crucial for selecting suitable crops, maximising fertilisation strategies and halting soil degradation. Soil composition impacts water quality, erosion control and the health of aquatic ecosystems. Knowledge of soil composition helps in sustainable agriculture practices and land development. Soils organic, humus or manure store significant amounts of carbon. Changes in soil composition can influence carbon sequestration and greenhouse gas emissions. The soil profile in the village showed a red fertile soil composition of organic/humus, topsoil, subsoil, subterranean and parent material layers. It is a good loamy soil, silty soil texture, of intermediate particle sizes, with moderate drainage and water holding capacity.

Whereas Nargahole National Park was the original area where these tribal villagers used to live, it is 20kms away from Rangayana Koppalu village to the western side. It was never abandoned, instead it is now 643 sq. km protected reserve area with a very high population of tigers and prey near to their

Events	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Season of the year	Winter- cool	Spring - sunny			Summer - hot		Monsoon - wet, hot, humid			Autumn - pleasant		Winter- cool
2022 Temperatures ^{0}C	24	26	31	34	32	28	25	25	25	25	24	23
2022 Rainfall (mm)	8	12	33	81	223	180	185	237	275	365	165	36
Floods						Flash floods,though floods are rare in the area,						
Cold/frost												
Dry period												
Land preparation				Rain-fed crops								
Planting - Maize							Harvested after 4 months					
Rice										Harvested after 3 months		
Foodgrains - Ragi									Harvested after 3 months			
Turmeric									Harvested after 10-12 months			
Ginger					Harvested after 7 months							
Beans			Harvested after 3 months									
Horticulture				Harvested throughout the year								
Harvesting											Rain-fed crops	
Lean period (Labourers)												
Food distribution				Food packages from both central government and state								

Figure 3. Seasonal Calendar - crops, rainfall, food distribution, *Source:* Authors; PRA (2023).

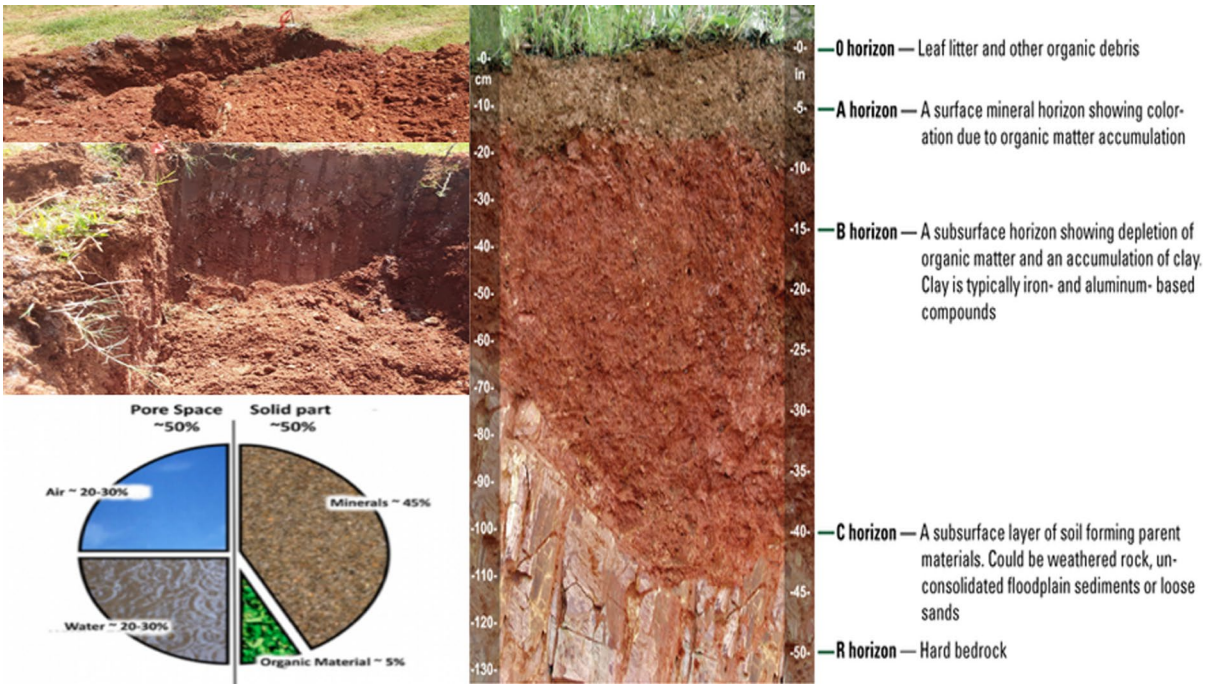

Figure 4. Village soil profile – Soil pits, soil composition and layers, *Source:* Authors; PRA (2022).

potential carrying capacity. The area has high fertile red soil suitable for cultivation, with 60 families who are still resisting eviction, including a school inside the forest. However, no other facilities, instead the families move out looking for employment in coffee farms adjacent to the forest. Both the biodiversity itself and the people who depend on natural resources for their livelihood are at risk as there is human-wildlife conflict. This is because people in and around the forest try to source products from the Nagarhole National Park. The conversion of the forest dwelling land into a protected area, the relocation of the villagers to a rehabilitation settlement did not consider the anticipated consequences attached to the land use change, food security and livelihood. The programme was more biased in supporting policies that conserve biodiversity and ignoring the relationship between human and forest dependences. The land to which the people were rehabilitated was not adequate and later converted into intensive farming, defeating the whole concept of trying to mainstream the Tribal population to the modern life and close to other India communities.

4.2. Demographic and socio-economic profile

Out of 150 households surveyed, male respondents comprised 72% and females 28%. This scenario shows a higher proportion of males in all age groups in the village and that 75% are either engaged in agriculture or agriculture wage employees, as compared to females (Figure 5).

Thus, the majority of the households fall within the casual employment category as wage labourers, earning a daily wage, whilst brick moulding activity also employing part-time workers (Table 1).

Respondents within the age group 31–60 years constituted the highest percentage of 43% representing the economically active group in sourcing livelihood and food provision for the families. The historical incidents and information came from the elderly age group (+61 years) who constitutes 23% of the participants.

In terms of food security indicated by food availability, the villagers are managing two meals per day, 6% are getting one meal, whilst 29% could afford three to four meals per day. This could be attributed to the government's monthly food scheme as every household receives food to supplement their own food source as 96% confirmed supply frequency of 12 times, meaning 12 months of the year (Table 2).

There is a sharp decrease in food types, hence an increase in frequency of households visiting the clinic for treatment due to food deficiency related health issues. The majority are consuming 1–5 types of food per month indicating that frequent consumption of one type of food is very high, leading to an unbalanced diet of the households (Table 3).

4.3. Food security index for the village

The estimated food security indices based on the four food dimensions revealed that the villagers are food insecure and currently have no strategies to improve it

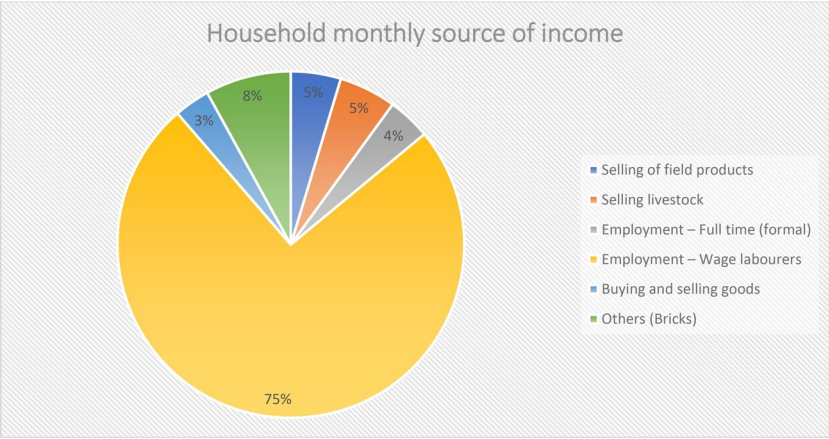

Figure 5. Household source of income: *Source:* Authors; field survey (2022).

Table 1. Demographic characteristics.

Age group (years)	Total respondents (no)	Per. (%)	Female (%)
<20	16	11	44
21–30	36	24	31
31–40	20	13	15
41–50	22	15	27
51– 60	22	15	18
61+	34	23	32
Total	150	100	28

Source: Authors; field survey (2022).

Table 2. Food availability per day and food supply frequency per year.

Meals per day	Per. (%)	Supply frequency per year	Per. (%)
1 meal	6	1–5 times	4
2 meals	65	6–10 time	0
3 meals	25	11–15 times	96
4 meals	4	16–20 times	0
Total	100	Total	100

Source: Authors; field survey (2022).

Table 3. Group of foods, fruits and vegetables consumed and clinic visit frequency per year.

Types of foods	Per. (%)	Clinic visit frequency	Per. (%)
1–5 types	89	1–5 times	4
6–10 types	8	6–10 time	81
11–15 types	3	11–15 times	15
Total	100	Total	100

Source: Authors; field survey (2022).

besides engaging into wage labour. This eventuality has been triggered by the rehabilitation programme as it broke the interconnectedness between land use changes and food security. The villagers' relocation from the forest areas led to food shortages, loss of opportunities to produce field crops for household consumption, besides curtailment of access to secondary food and NTFPs from the forest. This signifies that there is a close nexus between land use change and food security, which is lost in the process of rehabilitation as an undesirable outcome of such development interventions. Thus, as observed, in the rural communities the process of land conversion brings with it food security transformations [causing food insecurity] of the people who rely on natural resources or production from those lands (Kamwi et al., 2015).

Villagers responded to the pressure on land use change through adopting several strategies including diversified non-farm livelihood strategies, yet these options are not permanently accessible or available for them in rehabilitation sites. Hence Farah et al. (2021) indicated that understanding the ways in which people construct their livelihoods and food security in the milieu of rehabilitation and land use changes become crucial for formulating the strategies for the well-being of the village households.

In what follows, we examine the important aspects of household food insecurity based on the field surveys in the village and using the food security standard indices from WFP, FAO and USAID.

4.3.1. Household food insecurity access scale (HFIAS)

Data gathered from each family was computed to produce a household food insecurity index of 4. The index, which put a strong emphasis on food accessibility, quantified the severity of food insecurity. It was based on respondents' assessments of their households' food vulnerability over the previous 30 days, which comprised nine questions about specific occurrences that showed an overall rise in the severity of food insecurity. According to Coates et al. (2007); WFP (2008); USAID (2008); FAO. (2013), score above 6.6 is categorised as indicating severely food insecure with hunger.

4.3.2. Household dietary diversity score (HDDS)

The index was calculated based on household consumption of food items from 12 different food groups during the previous 24 hours (of the interview) at

household to measure utilisation of different foods. The foods were grouped into cereal, tubes, rich vegetables, rich fruits, meat, eggs, sea foods, legumes, milk, oils, spices and beverages. The results revealed that the consumption of different food items is at medium dietary diversity (FAO, 2013; Swindale & Bilinsky, 2006; USAID, 2008; WFP, 2008) with an index of 4.

4.3.3. Months of adequate household food provisioning (MAHFP)

The index measured the household's food availability during different months of the year. Months with households were unable to obtain adequate food were subtracted from twelve to get a score of 5 food insecure (Swindale & Bilinsky, 2010; USAID, 2008; WFP, 2016). Measuring this index provided indication whether the villagers have the desired outcome of improved food access, improved household food consumption as food access depends on the ability of households to obtain food from their own production, stocks, purchases, gathering, or through food transfers from relatives, members of the community, the government, or donors. As such, none of the respondents are able to produce their own food, as the FGD revealed villagers indicating that they are not engaged in agriculture activities due to shortage of land and lack of extension and other support services.

4.3.4. Food consumption score (FCS)

The index was used to measure utilisation through aggregating households' data on the diversity and frequency of food groups consumed over the previous 7 days, which is then weighted according to the relative nutritional value (Table 4).

The index was revealed as 29.4, which is the borderline score. It concurs with the Household Dietary Diversity Score, which indicated that the dietary diversity was at the medium level. The threshold levels used were: 'poor' FCS (0–21 scores), 'borderline' FCS (21,5 – 35 scores) and 'acceptable' FCS (INDDEX Project, 2018; WFP, 2008).

Table 4. Food consumption.

Food	Weight	Frequency (Av)	Weight x Freq
Main staples	2	4.5	9.0
Pulses	3	2.2	6.5
Vegetables	1	2.6	2.6
Fruits	1	0.0	0.0
Meat and fish	4	1.2	4.7
Milk	4	1.6	6.4
Sugar	0.5	0.1	0.1
Oil	0.5	0.0	0.0
Condiments	0	1.0	0.0
Total (score)			29.4

Source: Authors; field survey (2022).

4.3.5. Consumption coping strategies index (CSI)

The Consumption Coping Strategies Index calculated in Table 5 below was used to measure how the villagers coped with food shortage over 7 days. These were household coping strategies as short-term measures to increase food stability or decrease the number of people to feed, and dietary change. It measured managing food shortfall at household.
The index was 24.3, representing a medium score (USAID, 2008; WFP, 2016). This was attributed to the government food scheme covering the gap.

The Food Security Index (FSI) for Rangayana Koppalu village has been estimated as follows:

$$xFSIn = (zHDDSn + zFCSn + zMAHFPn + (-zCSIn) + (-zHFIASn)$$

where xFSIn is the composite food security index for nth household;zHDDSn is the HDDS Z-score; zFCSnis the FCS Z-score; zMAHFPn is the MAHFP Z-score; zCSIn is the CSI Z-score and zHFIASn is the HFIAS Z-score.

Therefore, $xFSIn = 4 + 29.4 + 5 + (-24.3) + (-4) =$ **10.03 (poor food security status)**.

4.3.6. Household income and expenditure surveys (HIES)

The index calculated the proportion of the entire income of the household that was spent on food (Table 6). A 79.1% index was revealed, showing a very vulnerable and consequently food insecure situation (Smith & Ali, 2007; USAID, 2008; WFP, 2016) in the village. The index confirms the fact that villagers are living in poverty, hunger and all incomes are diverted to food consumption. The in-depth interviews and FGD confirmed that members are borrowing money or opening loan accounts with the shop owners in the next village. They would then pay back at the end of the month using the farm wage earnings. Given that it is well known that households with lower incomes and more vulnerability have higher food expenditures, this is a sign of household food insecurity (Lele et al., 2016).

Majority of the households (58%) fall within the monthly income category of USD100 to USD500 (Table 7). However, in contrast, about 66% incur a monthly food cost in the range of USD 101–500. This suggests that majority of the households have very low-income levels per month and much of the income is spent on the purchase of food. Our survey also revealed that there are instances of borrowing by households to meet their monthly food

Table 5. Consumption coping strategies.

	Focus group ranking for each individual behaviour							Consensus
Strategy	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Average	Ranking
a. Less preferred food	2	1	0	2	1	1	1.2	1.0
b. Borrow food	1	2	1	2	1	1	1.3	2.0
c. Buy food on credit	2	1	2	1	2	1	1.5	2.0
d. Gather wild foods	0	0	0	0	0	0	0.0	4.0
e. Consume seed stock	0	0	0	0	0	0	0.0	3.0
f. Children to eat elsewhere	1	1	1	2	2	1	1.3	2.0
g. Household members to beg food	2	3	2	1	2	1	1.8	4.0
h. Limit portions size	2	1	2	0	1	1	1.2	1.0
i. Restrict adults intake	1	2	0	0	0	0	0.5	3.0
j. Feed workers	0	0	0	0	0	0	0.0	2.0
k. Reduce number of meals	3	2	1	2	1	0	1.5	1.0
l. Skip entire days without eating	1	1	0	0	1	2	0.8	4.0

	Raw score	Severity weight	Weighted score =
In the past 7 days, how many days has your household had to:	Sum of grp score/6	1,2,3,4	Frequency X Weight
a. Rely on less preferred or less expensive food	1.2	1	1
b. Borrow food from other households	1.3	2	3
c. Buy food on credit	1.5	2	3
d. Gather wild foods and immature crops	0.0	4	0
e. Consume seed stock	0.0	3	0
f. Send children to eat elsewhere	1.3	2	3
g. Send household members to beg food	1.8	3	6
h. Limit portions size at meal times	1.2	1	1
i. Restrict adults consumption for children to eat	0.5	3	2
j. Feed working members of the household only	0.0	2	0
k. Reduce number of meals per day	1.5	1	2
l. Skip entire days without eating	0.8	4	3
Total household score sum down the totals for each individual strategy			24.3

Source: Authors; field survey (2022).

Table 6. Household income and expenditure.

	Expenditure per month		
Revenues	Food items	Non-food items	Total
Less than USD100, (>Rs7,600)	69	33	102
USD 101–500, (>Rs 38,000)	33	4	37
USD 501 –1000, (>Rs76,000)	8	3	11
Calculation of the index			
Less than USD100, (>Rs7,600)	524,400	250,800	775,200
USD 101–500, (>Rs 38,000)	1,254,000	152,000	1,406,000
USD 501 –1000, (>Rs76,000)	608,000	228,000	836,000
Average of the totals	15909	4205	20115
Expenditure Index (food cost/ total cost)			79.1

Source: Authors; field survey (2022).

Table 7. Monthly incomes and monthly food purchases in USD.

Monthly income	Per. (%)	Monthly food cost	Per. (%)
<USD100	58	<USD100	29
USD 101–500	37	USD 101–500	66
USD 501–1000	4	USD 501–1000	5
USD 1001–1500	1	USD 1001–1500	0
Average monthly income	USD295	Average monthly food cost	USD406

Source: Authors; field survey (2022).

consumption and other requirements. The in-depth interviews on coping strategies revealed that borrowing and purchasing of food on credit were very high in the village.

The results above clearly indicated that the rehabilitation programme had some adverse impacts on food security. The relocation of the tribal people led to resettlement in areas with not enough land for agriculture or access to forest products. Munshi (2012) noted that as fifty to eighty percent of the food consumed by tribal people came from farming and gathering NTFP including nectar, foliage and petals, living in forests was essential to their sustenance, food security and culture. Food from the supplementary food system like forest therefore takes the place of food from the normal farming food system, especially when they become far too costly for the villagers to purchase. Therefore, the researchers suggest that future implementation of rehabilitation programme should consider food security as there is a potential threat of civil unrest, discrimination, health related diseases, including death due to malnutrition and hunger. Kusum (2018) revealed that food insecurity can cause negative impacts including discrimination, community unrest, socio-economic instability, hunger or health deterioration (Figure 6).

Our survey revealed that of these effects, the village under study is experiencing hunger and health deterioration amongst the communities, policy interventions are required to address the causes.

Food insecurity has been mainly caused by the lack of food availability, as the villagers are not producing their own food (Figure 7).

The rehabilitation programme contributed to low agriculture production and later caused the change of the farming system into intensive cultivation of commercial crops in the village. The commercial crops like bananas and cotton that are being grown in the village could not immediately give food to the community. Instead, the people have to use the income earned from banana and cotton cultivation to purchase food. Very often, the income they earn from banana and cotton cultivation needs to be ploughed back into farming again as these crops always face problems due to extreme weather induced droughts or wind damages in the case of banana and pests and diseases in the case of cotton. Therefore, the major cause of food insecurity is the food availability dimension caused by lack of production of food grains. This change to intensive monoculture farming resulted in unsustainable farming practices and land degradation as chemicals and other external inputs were applied. Intensive herbicide usage has resulted in the evolution of herbicide-resistant weed, greenhouse gas emissions, heavy soil and water pollution in the village and surroundings (Manalil, 2015). Hence, as intensive farming has an unbalanced impact on greenhouse gases pollutants, governments must place a strong emphasis on environmentally sustainable farming methods (Yugang, 2023).

4.4. Livelihood status index for the village

The measured status indices revealed unsustainable livelihoods and besides wage work, there are no other significant livelihood activities in the village. During FGDs and in-depth interviews, villagers strongly attributed this to eviction from forest and the subsequent rehabilitation programmes that resettled them outside their source of livelihood. The population depended on the forest products for domestic consumption and income generation. FAO (2014) indicated that rural communities generate income from forest products including firewood, beside forests are the main source of non-forest products. The tables below present the extent and trends of how the rehabilitation impacted on the livelihoods in the village. A five-point Likert scale was used to collect data on seven queries for each of the livelihood capitals, where 0 represented strongly disagree and 4 represented strongly agree.

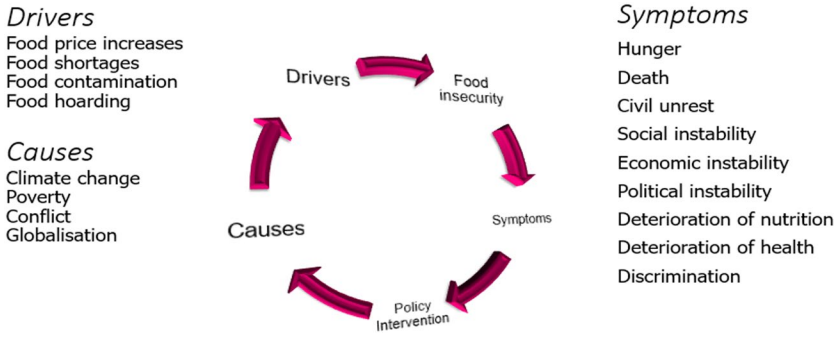

Figure 6. Food security as an issue: *Source:* Authors, 2023 modified after Kusum (2018).

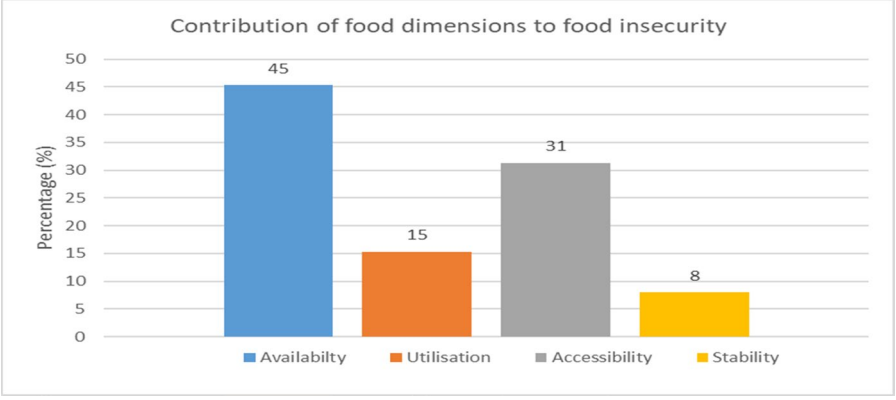

Figure 7. Contribution of dimensions to food insecurity; *Source:* Authors; field survey (2022).

Tables 8–13 present the computed status index of each of the livelihood capitals in the village.

4.4.1. Social status index

The results revealed that 66.7% strongly disagreed with the queries that were asked in this index. The villagers were not participating in business cooperatives or groups, no democratic space elect political leaders as rich people living nearby use money to buy votes. Most often, they are looking for work in the fields of wealthy farmers, which prevents them from finding time to organise and raise awareness about influence, power, or participation in decisions on changes to land use, relocation and livelihood choices.

The rehabilitated villagers are not yet mainstreamed or integrated into modern social life. In agreement with Pradeep and Kalicharan (2016), tribes are typically isolated groups of people who live in separation from outside influences. They have their own culture, unique subsistence methods, customs, superstitious beliefs and distinct lifestyles.

4.4.2. Economic status index

The results revealed that 82.1% strongly disagreed with the queries that were asked. There are few

Table 8. Scoring, frequencies and computation of social status index (SSI).

Opinion for social query	Weight *(Wi)	Query 1	Query 2	Query 3	Query 4	Query 5	Query 6	Query 7	Resp *(Fi)	(Wi)(Fi)	SS Index
Strongly Disagree	0	134	132	52	118	32		145	613	0	0.31
Disagree	1	15	16	15	28	12		2	88	88	
Neutral	2	1	2	9	4	13		3	32	64	
Agree	3			25		76	9		110	330	
Strongly Agree	4			49		17	141		207	828	
Total		150	150	150	150	150	150	150	1050	1310	

Source: Authors; field survey (2022).
**Note:* Wi: weight; Fi: no. of respondents.

Table 9. Scoring, frequencies and computation of economic status index (ESI).

Opinion for economic query	Weight *(Wi)	Query 1	Query 2	Query 3	Query 4	Query 5	Query 6	Query 7	Resp *(Fi)	(Wi)(Fi)	ES Index
Strongly Disagree	0		117	131	112	94	87	137	678	0	0.20
Disagree	1		29	12	31	41	58	13	184	184	
Neutral	2		4	6	7	12	3		32	64	
Agree	3	26		1		3	2		32	96	
Strongly Agree	4	124							124	496	
Total									1050	840	

Source: Authors; field survey (2022).
**Note:* Wi: Weight; Fi: no. of respondents.

Table 10. Scoring, frequencies and computation of human status index (HSI).

Opinion for human query	Weight *(Wi)	Query 1	Query 2	Query 3	Query 4	Query 5	Query 6	Query 7	Resp *(Fi)	(Wi)(Fi)	HS Index
Strongly Disagree	0	25	100	105	117			147	494	0	0.32
Disagree	1	52	41	38	20			3	154	154	
Neutral	2	58	6	5	12	82			163	326	
Agree	3	15	3	2	1	56	29		106	318	
Strongly Agree	4					12	121		133	532	
Total									1050	1330	

Source: Authors; field survey (2022).
**Note:* Wi: weight; Fi: no. of respondents.

Table 11. Scoring, frequencies and computation of physical status index (PSI).

Opinion for physical query	Weight *(Wi)	Query 1	Query 2	Query 3	Query 4	Query 5	Query 6	Query 7	Resp *(Fi)	(Wi)(Fi)	PS Index
Strongly Disagree	0	123	52	134		125	98	92	624	0	0.22
Disagree	1	27	48	16		25	31	58	205	205	
Neutral	2		13				13		26	52	
Agree	3		37		72		8		117	351	
Strongly Agree	4				78				78	312	
Total									1050	920	

Source: Authors; field survey (2022).
**Note:* Wi = Weight; Fi = No. of Respondents.

Table 12. Scoring, frequencies and computation of natural status index (NSI).

Opinion for natural query	Weight *(Wi)	Query 1	Query 2	Query 3	Query 4	Query 5	Query 6	Query 7	Resp *(Fi)	(Wi)(Fi)	NS Index
Strongly Disagree	0	24	134	12	41	54		35	300	0	0.29
Disagree	1	126	16	129	86	52		103	512	512	
Neutral	2			9	10	27		9	55	110	
Agree	3				13	17	121	3	154	462	
Strongly Agree	4						29		29	116	
Total									1050	1200	

Source: Authors; field survey (2022).
**Note:* Wi: weight; Fi: no. of respondents.

Table 13. Scoring, frequencies and computation of historical livelihood status index (HLSI).

Opinion for historical query	Weight *(Wi)	Query 1	Query 2	Query 3	Query 4	Query 5	Query 6	Query 7	Resp *(Fi)	(Wi)(Fi)	HLS Index
Strongly Disagree	0				4	4		3	11	0	0.68
Disagree	1			16		27		3	46	46	
Neutral	2			12	37	16	8	32	105	210	
Agree	3	32	7	22	15	9	9	18	112	336	
Strongly Agree	4	24	49	6			39		118	472	
Total									392	1064	

Source: Authors; field survey (2022).
**Note:* Wi = Weight; Fi = No. of Respondents.

economic activities and no activities diversification available to improve villagers' capacity to spend more. They are not receiving any capacity building on financial and resource management. The rehabilitation did not consider the fact that the resettled villagers required economic empowerment, which is a key capital in livelihood.

Malangmeih et al. (2015) reviewed that villagers' means of support, activities and assets are referred to as their 'livelihood', and any community needs economic activities like jobs, businesses, saving and credit to function.

4.4.3. Human status index

The villagers are employed in farms and in the leased land, responses reflected employment opportunities created by intensive farming, the women are easily employed to the leased fields. However, 61.7% strongly disagreed with the queries as they felt no adequate education facilities are present and that employers are not providing skills development for livelihood innovation. Human skills development is paramount for sustainable development in the village. As WCED (1987) indicated that sustainable development includes organising principle for meeting human skills development goals.

4.4.4. Physical status index

No significant own physical assets stocks noted, the little physical assets captured were utensils, small tools, motorcycles and that government provided electricity and roads in the village. Instead, Physical property consists of the vital facilities required to support sustenance (DFID, 2000). Therefore, no assets to dispose as a safety net to livelihood challenges, however, villagers believe that ownership of land and business equipment could improve their livelihood. A total of 78.9% of the responses strongly disagreed with the queries.

4.4.5. Natural status index

The index revealed that natural resources like land, soil and water are under threat of degradation, overgrazing and pollution. A total of 77.3% of the responses strongly disagreed that there are adequate natural capital stocks for their livelihood independence including grazing land. No environmental education nor land management activities to reduce degradation in the village. The villagers require skills in natural resources management. The growth of human skills is necessary to maintain the capacity of natural systems to deliver the resources and ecosystem services that are essential to the economy and society (WCED, 1987). If restoration result in land cover changing from sparse to dense and increased soil surface cover. It indicates improved ground surface resilience resulting in better prevention of erosion and degradation (Taye & Moges, 2021).

4.4.6. Composite livelihood status index

Normalisation factor = 100
Sum of SI Scores = 1.33
Number of SI = 5

Therefore, the overall Livelihood Status Index

$$\mathbf{LSI} = \frac{\left(\begin{array}{c}\mathbf{SSI\ score} + \mathbf{ESI\ score} + \mathbf{HIS\ score} + \\ \mathbf{PSI\ score} + \mathbf{NSI\ score}\end{array}\right)}{(\mathbf{Number\ of\ SI\ scores})}$$

$$= (\mathbf{0.31} + \mathbf{0.20} + \mathbf{0.32} + \mathbf{0.22} + \mathbf{0.29}) / \mathbf{5} = \mathbf{0.27}$$

$$\mathbf{Therefore\ LSI} = 0.27\,(\mathbf{unsustainable})$$

The FGD revealed that there were no livelihood interventions that were made during and after the rehabilitation programme, villagers have been struggling to generate income and sustain their livelihoods. Munshi (2012) indicated that the historically, tribal people harvested non-timber forest items including nectar, foliage and petals in addition to producing fifty to eighty percent of their food from forest farming (Figure 8).

Diversifying livelihoods is a good initiative and a solution to help increase household food security, particularly in rural areas. To attain national objectives for food security, the government should acknowledge and consider non-farm livelihood diversification methods (Kassegn & Endris, 2021). The importance of forests to the livelihood and food security of the Tribal population was supported in the result and responses from a historical livelihood status conducted. The measured historical livelihood status index revealed that the villagers had a sustainable livelihood.

4.4.7. Historical livelihood status index

A total of 56 elders aged 61 to 93 years were involved in the interview on historical livelihood status.

Status Index score = Sum of (*wi* multiple *fi*) divide by ***n*,** where,wi = Weight; fi = No. of Respondents; n = Total Respondents (56*7*4) = 1568

Therefore, Historical Livelihood Status Index = 0.68 (Sustainable)

The computation revealed that a total of 58.7% of the responses strongly agreed that villagers had land for farming and a diversity of livelihood activities that included trading of forest products. Sarmah and Arunachalam (2011) highlighted that over 500 million people depend on non-timber forest products for subsistence and cash income. Households living in and around forests earn 40–60% of their income from the sale of non-timber forest products (Nayak et al., 2014).

5. Conceptual framework for sustainable land use, food security and livelihoods

With the realisation of the adverse impact of the rehabilitation programme which was an outcome of forest policies applied in the formulation of National Parks, a conceptual framework was developed for the specific context of the Rangayana Koppalu village. The dimensions for livelihood and food security were borrowed from the sustainable livelihood approach and the food systems approach respectively. This conceptual framework interlinks the land use change (causes and effects), livelihood capital/assets (natural, physical, social, financial and human) to the social, economic and environmental dimensions with the availability, utilisation, accessibility and stability of food to the community. Human preferences in the framework: the villagers would exploit the land and any other natural resources for livelihood and food production. The natural resources, especially land and forest will go under stress leading to land use change as the population try to produce more livelihoods outcomes and high production. Whereas, institutional processes would also influence by reinforcing policies on land use, livelihoods and food security to reduce vulnerability, land degradation, deforestation and protect forest and wildlife. The

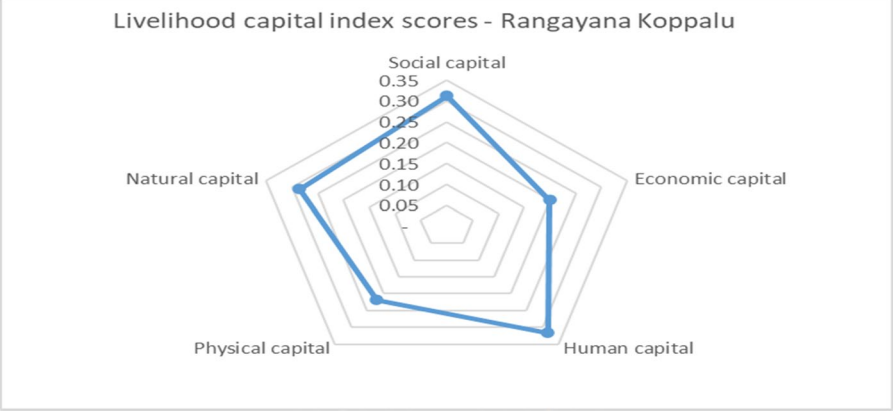

Figure 8. Index scores of livelihood capitals; *Source*: Authors; field survey (2022).

framework characterises trade-offs on implications of land use change and ecosystem service in terms of two dimensions of service conflicts, the biophysical constraints and divergent values (Figure 9).

The trade-offs emanate around land use, livelihood and food security, whereby there will be productivity at the expense of biodiversity conservation. This is a scenario of land use and livelihood activities for food security; and two services are generated, for **service B**, it will ensure food security to the community and **service A,** will be land use and livelihood activities. In this scenario, there will be a need for the stakeholders to get together, review their individual interests and compromise to achieve the dimensions of land use, of livelihood and that of food security.

6. Conclusion

The rehabilitation programme implemented in Rangayana Koppalu had a huge impact on land use change, thereby on the food security and livelihood of the villagers. The shortage of land affected agriculture production for farming of diversified products (food security) which could have made the Tribal people start generation income (livelihood). The land provides most of the ecosystem services needed to produce food and conduct livelihood activities, this entails that the rehabilitation programme broke a close link between the delivery of food security, livelihood and land use. The proposed conceptual framework bridges this gap through encouraging consultation process, brings together the dimensions of land use, food security and livelihood which are important in

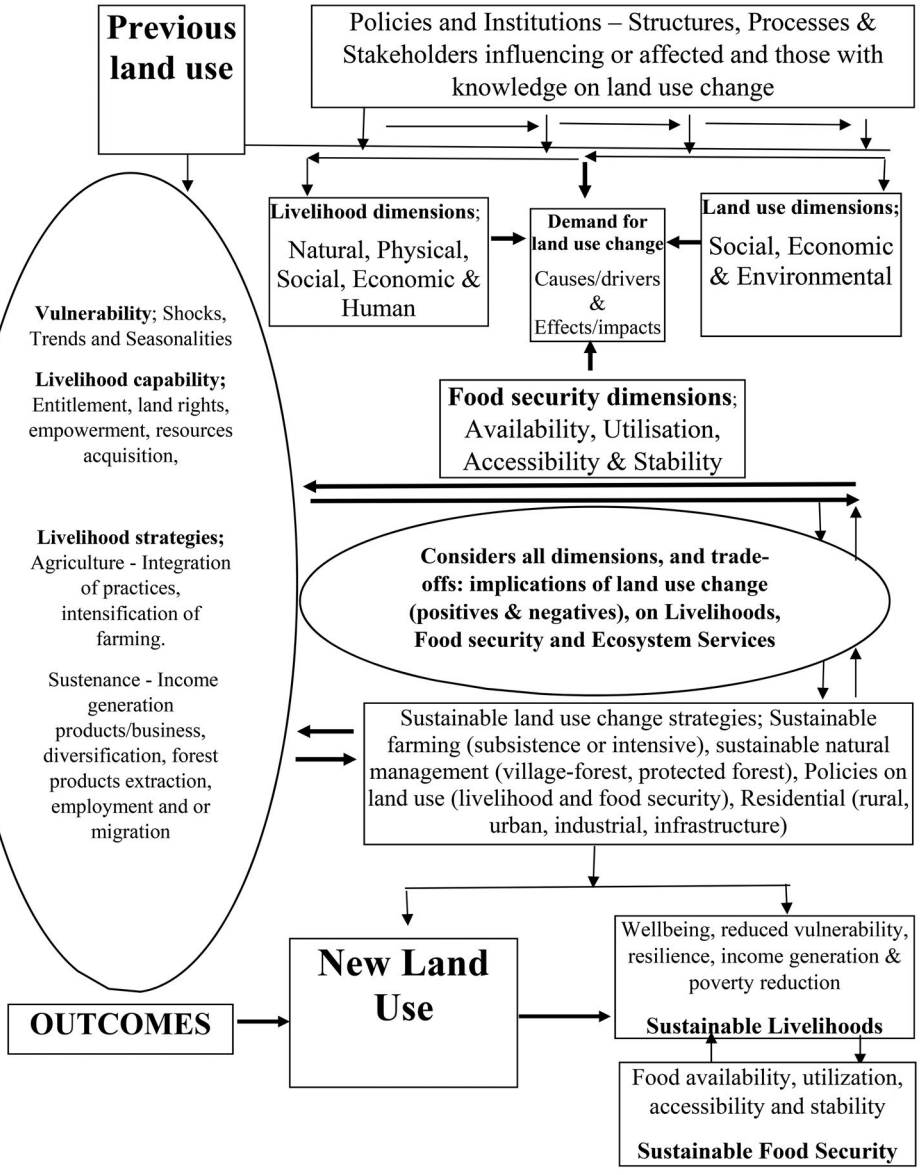

Figure 9. Integrated framework on land use change, food security and livelihood. *Source:* Authors (2023).

decision making about the three components. The adoption of the framework has a potential to influence proper land use change transition without compromising sustainable food security and livelihood. Policies on forests are to consider undertaking a cost benefit analysis before eviction and rehabilitating people. Policies should also make provisions for proper stakeholder consultations before implementation of the rehabilitation and resettlement programmes.

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Author contributions

Conceptualization, D.M and M.P; methodology, D.M. M.P, P.K.V. and S.M.; data collection, D. M; data analysis, D.M. and M.P; writing original draft, D.M; writing - review and editing, M.P, P.K.V. and S.M; supervision and monitoring, M.P. All authors have read and agreed to the published version of the manuscript.

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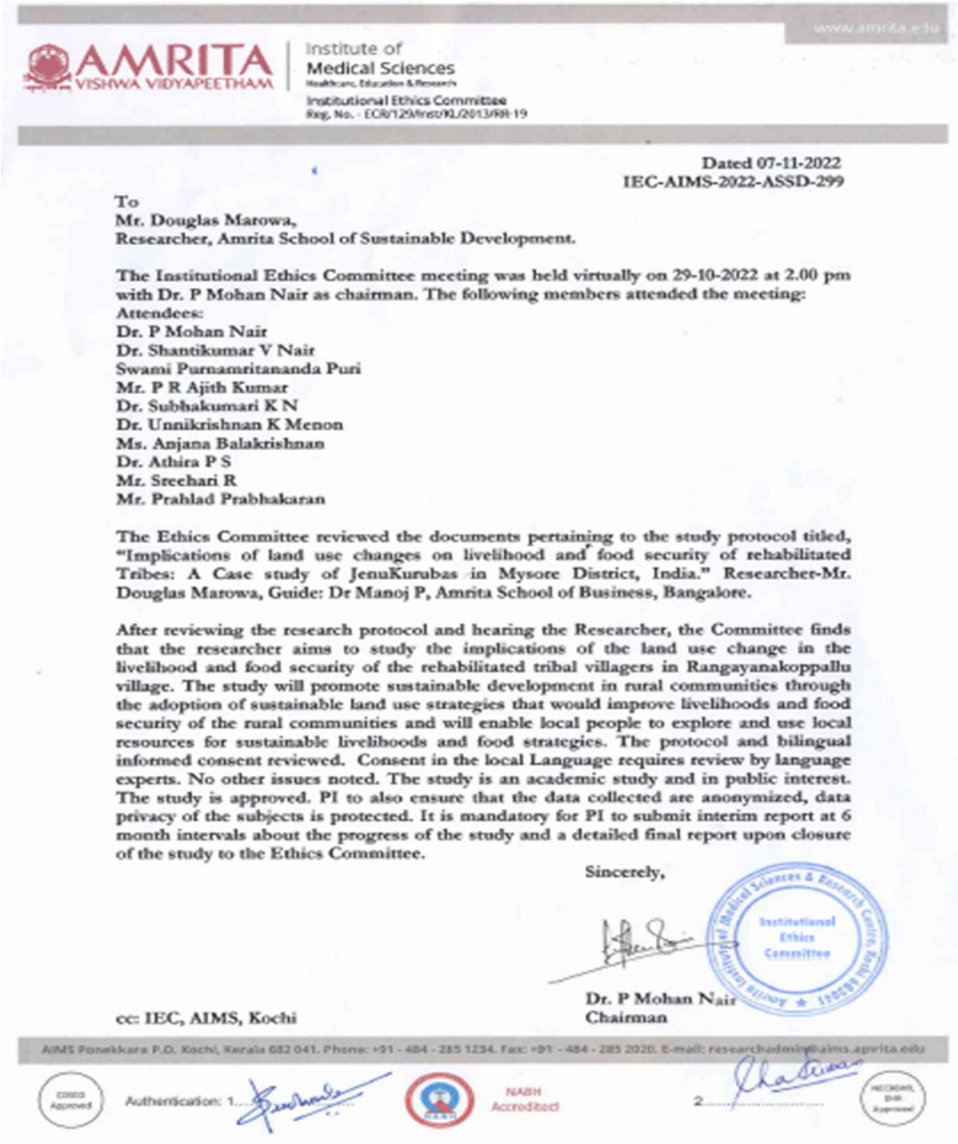
Appendix 1

Ethical Clearance certificate – the research is from a thesis objective.



AMRITA VISHWA VIDYAPEETHAM | Institute of Medical Sciences
Healthcare, Education & Research
Institutional Ethics Committee
Reg. No. - ECR/129/Inst/KL/2013/RR-19

Dated 07-11-2022
IEC-AIMS-2022-ASSD-299

To
Mr. Douglas Marowa,
Researcher, Amrita School of Sustainable Development.

The Institutional Ethics Committee meeting was held virtually on 29-10-2022 at 2.00 pm with Dr. P Mohan Nair as chairman. The following members attended the meeting:
Attendees:
Dr. P Mohan Nair
Dr. Shantikumar V Nair
Swami Purnamritananda Puri
Mr. P R Ajith Kumar
Dr. Subhakumari K N
Dr. Unnikrishnan K Menon
Ms. Anjana Balakrishnan
Dr. Athira P S
Mr. Sreehari R
Mr. Prahlad Prabhakaran

The Ethics Committee reviewed the documents pertaining to the study protocol titled, "Implications of land use changes on livelihood and food security of rehabilitated Tribes: A Case study of JenuKurubas in Mysore District, India." Researcher-Mr. Douglas Marowa, Guide: Dr Manoj P, Amrita School of Business, Bangalore.

After reviewing the research protocol and hearing the Researcher, the Committee finds that the researcher aims to study the implications of the land use change in the livelihood and food security of the rehabilitated tribal villagers in Rangayanakoppallu village. The study will promote sustainable development in rural communities through the adoption of sustainable land use strategies that would improve livelihoods and food security of the rural communities and will enable local people to explore and use local resources for sustainable livelihoods and food strategies. The protocol and bilingual informed consent reviewed. Consent in the local Language requires review by language experts. No other issues noted. The study is an academic study and in public interest. The study is approved. PI to also ensure that the data collected are anonymized, data privacy of the subjects is protected. It is mandatory for PI to submit interim report at 6 month intervals about the progress of the study and a detailed final report upon closure of the study to the Ethics Committee.

Sincerely,

Institutional Ethics Committee

Dr. P Mohan Nair
Chairman

cc: IEC, AIMS, Kochi

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Authentication: 1. 2.

NABH Accredited