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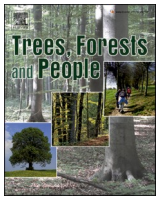

The linkage between forests and household food security: Empirical evidence from Shinyanga Region, Tanzania

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ABSTRACT

Many rural forest dependents are still poor and exposed to food insecurity. Hence, this paper aims to study the linkage between forests and household food security by analysing factors that determine participation in forest activities and by examining differences between participants and non-participants in respect of the food-security outcome. The study was conducted in rural areas of the Shinyanga Region in Tanzania using cross-sectional data on a sample of 303 rural households. Marginal effects predicted that distance to the forest concerned, illness or death of a household member, and off-farm activities determined participation in forest activities. Propensity score matching revealed that those who participated in forest activities were less food secure than non-participants with comparable characteristics were, which supports the contention that rural forest dependents are prone to food insecurity. Government policy should, therefore, aim at enhancing alternative sources of income as well as food storage facilities and food production for rural households.

1. Introduction

This paper presents a study on the linkage between forest use and food security for rural households in Tanzania's Shinyanga Region. The study objectives are to explore factors that influence households' participation in forest activities, and to establish whether – and, if so, how – such participation affects households' food security.

Even with economic and agricultural advancement, many rural households in developing countries still depend on forests to support their livelihoods and for food security (Ali and Rahut, 2018; Angelsen et al., 2014; Ntiyakunze and Stage, 2022). Forests are perceived as generally being more important to rural poor households than to the non-poor, since the latter have more options for sustaining their livelihoods (Wunder et al., 2014). A large portion of poor households in rural areas derive benefits from forests for their daily subsistence and survival, as well as for distributing income and reducing poverty (Fonta et al., 2011; Hussain et al., 2019). Forests have three potentially distinctive roles in supporting rural livelihoods: they can act as a safety net, supporting livelihoods in times of shocks to other income; they can support daily consumption needs as a coping strategy; and they can help reduce poverty by enabling a sustainably higher household income (Angelsen and Wunder, 2003; Kabubo-Mariara and Gachoki, 2008; Pattanayak and Sills, 2001).

Despite these livelihood benefits, many forest-dependent households in rural settings are poor and, therefore, exposed to food insecurity (FAO, 2011). Several authors have raised their concern that, in practice, forests may be poverty traps (Angelsen and Wunder, 2003; Kabubo--Mariara and Gachoki, 2008; Mulenga et al., 2017). In this context, poverty traps occur when rural households rely on forest activities that yield low returns on their labour such as collecting non-timber forest products (NTFP) for example firewood, thatches and forest foods. Poor households are obliged to rely on such low-return activities as a last resort because they lack other income-earning opportunities. At the same time, however, these low-return activities tie up much of the household's labour, leaving little room to develop higher-return activities. Faced with this bleak outlook, rural household incomes remain low, which has negative long-term consequences for their livelihoods and food security. Rather than helping to raise the long-term income of the households, the forests thus act as poverty traps, helping the households survive but at the same time effectively locking their labour into low-return activities. However, other studies (Ali and Rahut, 2018; Chukwuone and Okeke, 2012) found that participation in forest-based livelihood activities such as collection and consumption of forest products examples wood, honey, fruits and vegetables impacted rural

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household income positively and helped to reduce poverty instead of being poverty traps. This apparent contradiction as to the impact of forests on the rural poor and their food security motivated the current study, namely, to determine the relationship between poor rural households and forest use and then establish the link between forests and household food security. The use of policy-relevant knowledge and data on the contributions of forests to food security are recognized to be important for improved food security in Tanzania and other developing countries (FAO and MNRT, 2020). For any appropriate forest-related policy or programme to work, the first need will be to understand the socio-economic characteristics of, and forest utilisation by, the households concerned (Pandey, 2010). Previous studies highlight households' socio-economic characteristics such as age, income, off-farm activities and sex are associated with forest dependence and participation in forest activities (Chhetri et al., 2013; Rahut et al., 2015; Garekae et al., 2017; Ntiyakunze and Jesper, 2022)

Most work on the topic of forest dependence and food security has primarily been qualitative in nature (Arnold et al., 2011; Falconer and Arnold, 1991; FAO, 2016; Sunderland et al., 2013). One of the few quantitative studies on the topic to date – and from which the current research draws inspiration – was conducted by Abadi (2017) in Tigray in northern Ethiopia. The latter study analysed the differences in food security outcomes between those who participated in extracting forest environmental resources i.e. collection and consumption of non-timber forest products and those who did not. The study found that higher education, being involved in off-farm activities, and awareness of climate change reduced participation in forest extraction activities. It was also found that participants had significantly lower food-security outcomes and were relatively poorer than non-participants. A similar approach was adopted by Rahut et al. (2015) in a study on household participation in community forest management programmes. This study discovered that households participating in such programmes had higher levels of income and food security than their non-participating counterparts. Thus, these earlier economic studies of the links between forest use and food security produced mixed results.

Other research has established unequivocally that forests support the four pillars of food security, i.e., food availability, food accessibility, food stability and food utilisation (FAO, 2016; Sunderland et al., 2013). At the household level, the availability of forest foods such as mushrooms, fruit and bush meat can support food security. Although forest foods contribute only minimally to such security, i.e., offering around 0.6 % of the global food supply (Sunderland et al., 2013), they are a significant supplement to staple foods and provide vital micronutrients to their users (Falconer and Arnold, 1991; Broegaard et al., 2017; Chukwuone and Okeke, 2012; Cooper et al., 2018; Milbank, 2023). In terms of food accessibility, because forests are a source of income from, for example, the sale of forest products and forest-related employment, this can increase access to food by purchasing it (Chukwuone and Okeke, 2012). Regarding the food stability pillar, forests provide a safety net to households because they can access forest foods as a supplement during cyclical or sporadic periods of other food shortages due to drought, illness, or other external shocks (Arnold et al., 2011; Falconer and Arnold, 1991; Sunderland et al., 2013). In respect of the food utilisation pillar, forests provide fuelwood for cooking purposes (FAO, 2016; Karki et al., 2017). As mentioned earlier these studies are qualitative in nature and this provides a room for quantitative studies to be conducted.

Thus, although forests offer some households a safety net during crises, other households depend on them daily for subsistence and a source of income. Hence, the current study considers forests in all roles. A further contribution made by this study is to supplement existing scant data on forests and food security in Tanzania (FAO and MNRT, 2020) by seeking to answer the following questions: *Do participants and non-participants differ socio-economically*? *What are the determinants of participation in forest activities*? And *what are the differences between participants and non-participants in forest activities in respect of food-security outcomes*? These questions are also significant for forest policy because food security at household level necessarily includes a careful examination of the livelihoods of forest-dependent households, it is vital that forest policy approaches are appropriately informed and able to take such households into account.

2. Background

Tanzania is amongst the countries with worst food security in the world (Rashid et al., 2024). About 55 % of the country's population experience either moderate or severe food insecurity (Randell et al., 2022; FAO, IFAD, UNICEF, WFP, WHO, 2020); however, food security varies across regions and seasons (Baffes et al., 2019). Compared to urban households, food insecurity is more prevalent amongst the rural poor households in the country (Haule and Mwamfupe, 2016; Kahimba et al., 2015). For instance, poverty incidence and food poverty in rural areas are 31 % and 9.7 %, respectively, whereas in urban areas they are 15.8 % and 4.4 %, respectively (NBS, 2018). Poverty exacerbates food insecurity because poor households may not have adequate resources to access food especially during periods of higher food prices (Randell et al., 2022). At the same time, the poorest are the most forest reliant (Dokken and Angelsen, 2015) and this is a similar finding to a study conducted in Southern Malawi by Fisher et al. (2010). These findings suggest that poverty, food security and forest dependence are interconnected.

Tanzania loses about 469,000 hectares of forests per annum in deforestation due to high forest dependence and poor forest management (FAO, 2020). Deforestation has impacts on income, livelihoods, ways of lives of forest dependents and compromise the provision of ecosystem services necessary for food security and nutrition (HLPE, 2017; Arnold et al., 2011). Droughts and poor rains caused by deforestation affect agricultural production and consequently contribute to food shortages at the national level (NBS, 2014). With much dependence on rainfed agriculture, Tanzania's food security is often jeopardized by weather shocks (Kahimba et al., 2015). Deforestation has also caused reduced availability of, and consequent reduction in the collection and consumption of, forest foods and other forest products which rural forest dependents rely on for income and ensuring food security (Hall et al., 2022).

The above background shows that the interplay of forests and food security in Tanzania is multifaceted. With about 75 % and 65 % of the Tanzanian population living in rural areas where most forests are located and relying on agriculture, respectively (Randell et al., 2022), understanding the linkages between forests and food security is important for improving food security, promoting sustainable forest management and poverty alleviation.

3. Methodology

3.1. Description of the study area

The empirical data for this study's analysis were obtained in the rural areas of the Shinyanga Region in north-western Tanzania. The Region is characterised by semi-arid climatic conditions and there is widespread reliance on community and government forests. The Region experienced massive deforestation and forest degradation over the years due to several reasons such as agricultural expansion and increased wood demand (Wainaina et al., 2021). In response, community conserved forests given the traditional name of *Ngitili* were introduced in 1984 (Malunguja and Devi, 2020). Thus, local communities became mainly responsible for conserving and managing the forests. However, deforestation and forest degradation are still high in the region due to extensive grazing and high demand for forest products such as fuelwood and charcoal (Putri and Kweka, 2015). The aftermath effects of deforestation and forest degradation affect the rural forest dependents' livelihoods in the Region. Some of these effects are the long dry spells and erratic rainfalls which lead to subsequent poor harvests and reduced food security

amongst the households in the region (IPCC, 2020).

Moreover, the Region ranks as the third poorest region in the country (URT, 2017). The severity of poverty in Shinyanga Region is 3.2 %, which is worse than the 2.5 % average for the country (Kilama, 2016 as calculated from 2011/12 Household Budget Survey and 2012 Census). Additionally, the Region's poverty headcount ratio of 64 % is above the national average of 47 % (URT, 2017). Therefore, given the above background and that poverty influences forest dependence and food security, this Region deserved special attention.

3.2. Research design and sampling

This study employed a quasi-experimental research design. The design was centred to determine the cause for the differences in participation in forest activities, and differences in food security outcomes for the preexisting groups of households. Unlike true experiments where assignment of treatments is random, in quasi-experiments assignment of the treatments is by self-selection (Maciejewski, 2018; Cook, 2015). Thus, the study involved the self-selection of the treatment (participants in forest activities) and control (non-participants in forest activities) groups. *Participants* were households involved in both extraction and consumption activities. These activities included collection, harvest, sale and consumption of non-timber forest products. *Non-participants* were households that may consume non-timber forest products, but that did not take part in forest extraction activities.

The study's population were the rural households in Shinyanga Region, and cross-sectional data were collected in September and October 2018. The Region comprised of five districts according to 2012 national census, namely Shinyanga Urban, Kahama Urban, Kishapu, Shinyanga Rural and Kahama Rural. Since the study's unit of analysis was the rural households, Kahama Rural and Shinyanga Rural districts – were selected. Kahama Rural and Shinyanga Rural districts respectively were represented by random samples of 122 and 181 households, with sample sizes determined by relative population of the disctricts in question. This made a total random sample of 303 rural households selected from both districts. Then from each district, a proportionate random sample of 16 wards was selected. From these wards, a total of 16 villages were randomly selected with at least 7 households from each village. These villages were selected based on the following criteria to ensure representativeness: (i) villages with forests regardless of forest management type (ii) villages with forest dependents. Households practising private forestry were later excluded from the econometric analysis because they were far better off financially and had larger land holdings (Ntiyakunze and Stage, 2022) and did not share similar characteristics with those depending on community and government forests. The predetermination of the districts, wards and villages was also based on the above-mentioned criteria.

3.3. Data collection and ethical consideration

The current study used both primary and secondary data. Primary data were collected using a household questionnaire. A questionnaire was administered to a random sample of 303 heads of households. Where the head was not at home, a household member with full information and aged 18 and above was interviewed instead. The questionnaire, which was conducted in the national language, Swahili, to maximise the quality of responses, consisted of three sections. The first covered questions on the nature of socio-economic information about the household, such as the age of the household head, household size, and the nature of household expenditure. The second section focused on questions regarding forest dependence, while the last section covered questions on household food security, shocks to that security, and consequent coping strategies. The definition of food security follows that of World Food Summit (1996) which states that "food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for active and healthy life''. Food security outcomes here, therefore cut across this definition (see Table 3). Secondary data were collected from the Shinyanga Region offices to obtain data on the socio-economic profile of the region, and districts. Literature reviews from publications and reports were also used to supplement and complement the study's findings.

Prior to data collection, this study obtained an ethical clearance from the University where the principal investigator was based. The ethical clearance was then submitted to the regional office followed by the district offices to get the research permits. Permit from each district was then submitted to each district's wards offices which provided research permits to be submitted to the village offices. Each village office was then presented with its ward permit. After being granted permission from the village offices, the researcher and research assistants guided by the local assistant were able to collect data. During data collection, respondents were informed of the purpose of the research activity, interview time, and the confidentiality of their responses. Respondents were also informed that their participation was voluntary. Only those who gave consent were interviewed, and those not willing to respond were left out.

3.4. Data analysis

3.4.1. The model for determining household participation in forest activities

While all households in this study were farmers, some were additionally involved in economic activities such as those related to forests. Hence, households were categorised into two groups, i.e., those who participated in forest activities and those who did not. The few respondents who had planted private woodlots on their own farms had larger land holdings (and higher income) than the other respondents and were excluded from the analysis. The descriptive statistics were then analysed to establish any similarities and differences between forest-activity participants and non-participants. The next step involved isolating the factors that determined household participation in forest activities by using an econometric approach.

Households potentially had access to two relatively secure, and two more uncertain, sources of income. Off-farm wage income is secure when available, but very few households had permanent formal employment in the public or private sector, owing to a lack of skills and poor investment in rural areas. Collecting non-timber forest products also provided a secure source of income. Returns from agriculture, on the other hand, were uncertain due to various related shocks, such as poor rains. Starting up small businesses was also an uncertain source of income in the area, owing to risk factors such as low initial capital and the long wait for profit. Thus, a risk-averse household may prefer to devote labour to forest activities to obtain secure returns. Different households will optimise differently, depending on how easily they can access forests, for example, or how easily they can acquire off-farm wage income. However, their time allocation to the various uses of their labour will additionally depend not only on the relative expected returns to such uses, but also on the household's risk aversion. A risk-averse household may prefer low-return but safe activities, rather than high-return but uncertain activities – even when both uses for their labour are available. Thus, labour may be allocated to forest activities because they are highly profitable, in line with the proposition that forest use can improve overall income, and in which case forest use should be linked to improved household income and food security outcomes. However, labour may also be allocated to forest activities because they are less risky, in line with the proposition that forest use is a coping strategy and implying that forest use may be linked to worse outcomes. If a household head dies or becomes ill, the overall available time will diminish, possibly leading to the household focussing more on safer uses of labour, such as collecting forest products, in line with the proposition that forest use is a means of dealing with shocks, and also implying a link to worse outcomes. This means that the net impact of forest use on income and on food security is an empirical issue and will depend on why the forest use

takes place.

Given this background, the decision by a household to participate in forest activities depends on the benefits of participation (Kabubo-Mariara and Gachoki, 2008). Hence, the probability of household *i* participating in forest activity can be expressed as –

$$y_{i^*} = \beta_i X_i^{'} + \mu_i \quad (6)$$

$y_i = 1$ if $y_{i^*} > 0$, i.e., if household *i* decides to participate

$y_i = 0$ if $y_{i^*} \leq 0$, i.e., if household *i* decides not to participate where y_i is the decision by household *i* to participate in forest activities, $X_i^{'}$ is the vector of explanatory variables as described in Table 1, β is the coefficient of explanatory variables, and μ_i is a random error term.

Since the dependent variable (*Participation in forest activities*) was binary, a logit regression model was used to estimate the determinants of participation. Households' participation was categorised into a binary variable, i.e., participants and non-participants. While *non-participants* are households that may consume non-timber forest products, they do not take part in forest extraction activities; *participants*, on the other hand, are households that are involved in both extraction and consumption activities. Forest income, quantities of forest products extracted for own use and sale, number of forest activities in which a household is involved, etc. are factored to assess whether there are differences amongst participants. Based on these factors, those who do participate are rather similar in their participation levels. Therefore, the decision of whether to participate in forest activities or not is likely to be a function of socio-economic factors (e.g., age and education of the household head, household expenditure, household size, and access to off-farm income) and geographic factors such as distance to the forest concerned (Ali and Rahut, 2018; Cooper et al., 2018; Fonta et al., 2011; Pandey, 2010; Lepetu et al., 2009; Fisher, 2004, who found these variables to matter). The variables relating to security shocks were also included so that their influence on the household head's decision to participate in forest activities could be estimated.

3.4.2. Propensity score matching: linkage between forests and household food security

Propensity score matching (PSM) was used in the current study to analyse the linkage between food security and forest use by comparing household food-security outcomes or indicators and household participation in forest activities. PSM is useful because it attempts to reduce the bias associated with estimating the effect of a treatment (Hade and Lu, 2014), and it corrects for a potential bias in sample selection that may arise due to systematic differences between treatment participants and non-participants (Rahut et al., 2015). Also, even when experimental data are missing, PSM is appropriate for estimating the impact of participation in a treatment – here, forest-based activities – on food security for households that are otherwise comparable (Ali and Rahut, 2018). Ideally, a propensity score shows the probability of assigning a treatment (Austin, 2011), i.e., participation in a treatment is conditional on observable characteristics. The matched sets of the treated and untreated subjects sharing similar values of a propensity score are entailed by PSM (Rosenbaum and Rubin, 1983, in Austin, 2011). The covariates used for matching in this study are presented in Table 1.

4. Results

4.1. Household socio-economic characteristics and food security outcomes

Table 1 presents comparative descriptive statistics from our survey. Compared with participants, non-participants reported higher levels of average household expenditure, off-farm income, and education. On average, therefore, non-participants were socio-economically better off than their counterparts.

The main economic household activity for all respondents was reported as farming of food and cash crops. The major crops produced included maize, rice, groundnuts, sweet potatoes, beans, cassava, and cotton. Some households also engaged in other activities such as forestry (e.g. producing charcoal and selling honey), fishing, working at mines, running businesses (e.g. transport by motorcycle), and formal employment in the public and private sectors. Notably, some of the forest products were not marketed; hence, their shadow values were estimated (using their market prices at the nearest available market) and included as part of household income.

Table 2 indicates the relative types and proportions of forest dependency in Shinyanga Region, which reveals that the proportion of participants is comparatively very high, implying that household

Table 1
Descriptive statistics.[11]

Variable	Definition of the variable	Participants ($n = 220$)				Non-participants ($n = 66$)			
		Mean	Std dev.	Min.	Max.	Mean	Std dev.	Min.	Max.
Education	Number of years household head spent in school	5.14	3.63	0	13	5.16	3.83	0	15
Sex	(Dummy variable) Sex of household head (1 = Male, 0 = Female)	0.84	0.84	0	1	0.86	0.35	0	1
Household size	Number of people living in the same household	4.82	2.09	1	10	4.74	1.97	1	9
Age	Age of household head (years)	47.50	14.64	20	96	46.39	11.66	27	80
Expenditure	Total household expenditure per month	62,555	72,394	1000	750,000	65,045	77,414	10,000	500,000
Livestock ownership	(Dummy variable) Household owns livestock (1 = Yes, 0 = No)	0.56	0.49	0	1	0.42	0.49	0	1
Off-farm activities	(Dummy variable) Household also engages in off-farm activities (1 = Yes, 0 = No)	0.50	0.50	0	1	0.57	0.49	0	1
Distance to the forest	Distance of household residence to nearest forest (minutes)	25.40	26.77	1	200	48.86	53.59	5	240
Size of land held	Total amount of land that household head holds (acres)	8.05	11.96	0	200	5.39	5.26	1	25
Forest degradation awareness	(Dummy variable) Household head knowledgeable about forest degradation (1 = Yes, 0 = No)	0.38	0.49	0	1	0.26	0.44	0	1
Drought shock	Number of times household head affected by drought in the past ten years	1.71	2.42	0	10	0.47	1.82	0	9
Crop pest	Number of times household head affected by crop pests in the past ten years	2.95	3.07	0	14	3.18	4.05	0	20
Agricultural output price shock	Number of times household head affected by falling agricultural output prices in the past ten years	1.25	1.97	0	10	1.59	1.91	0	10
Loss of livestock shock	Number of times household head affected by the death of livestock in the past ten years	1.26	2.84	0	20	1.45	3.10	0	10
Death or illness of a household member	Number of times household head affected by illness or death of a household member in the past ten years	1.63	4.33	0	25	0.23	1.29	0	10

Table 2
Types and proportions of forest dependency in Shinyanga Region.

Type of forest dependency	Number	Percentage
Participates in forest activities (*Participant*)	220	72.61
Does not participate in forest activities (*Non-participant*)	66	21.78
Self-reliant (*Owner of private forest*)	17	5.61
Total	303	100

dependence on forest resources is paramount in the region.

Participants were primarily farmers (see Table 1), but they also reported being involved in collecting and extracting NTFP such as fuelwood (for cooking), mushrooms (for food), wild fruits (for food) and grass (for thatching). Participants also collected some of these forest products to sell them, i.e., as a source of income for their daily subsistence. For example, some participants were charcoal producers and traders of forest fruits and vegetables in the local markets. Some participant households had to depend on collecting and extracting NTFP when they needed emergency cash during a crisis such as the sudden death or illness of livestock, or the loss of crops to pests and drought. For participants, the average forest income, expressed as a share of total income, was found to be 23 %; hence, forest income makes a fair contribution to the total. Households in the region reported depending mainly on community and government forests.

Non-participants comprised 21.78 % of the total sampled household heads. Non-participant households were mainly occupied with farming, although they also engaged in some off-farm activities. *Owners of private forests* were farmers too, but as noted earlier, their relatively low numbers and different socioeconomic circumstances excluded them from the estimations.

As regards household food security, the descriptive statistics show that, for the three years for which data were collected in 2018, i.e., for 2015, 2016 and 2017, participants experienced more food shortages on average than non-participants did (see Table 3). This implies that, on average, participants were less food-secure than non-participants. From other food-security indicators, participants were again less food-secure and had lower levels of sufficient food than non-participants did. At the start of this section, it was noted that non-participants were socio-economically better-off than their counterparts; this distinction between the two groups was also evident in respect of their food security status. For example, the factors affecting food security were generally reported as being inadequate food stocks due to drought, small land size, crop pests, high food prices, insufficiently effective farm implements, poor income, late rains, or a delay of the farming season. Households also reported having experienced at least two months of food shortages in respect of the three-year data period, especially between November and February.

Table 4 shows that households either produced their own food, purchased it, or did both. Table 4 also shows that very few households relied exclusively on purchased food, whereas many households produced their own food and supplemented it with purchased food.

The types of foods eaten included maize (main staple food), rice, cassava, meat, beans, and other vegetables. Households also consumed some forest foods, especially mushrooms, either by collecting them directly from forests or by purchasing them from local markets. Forest foods, used primarily as a supplement, were reportedly more available during the rainy season.

Table 3
Household food-security indicators.

Food-security indicator	Participants (n = 220)		Non-participants (n = 66)	
	Yes	*No*	*Yes*	*No*
Household experienced food shortage in the past three years (Yes/No)	81.82 % (180)	18.18 % (40)	69.70 % (46)	30.30 % (20)
Household was worried about having enough food in the past seven days (Yes/No)	59.09 % (130)	40.91 % (90)	53.03 % (35)	46.97 % (31)

Food-security indicator	*Household frequency*	*Mean number of days*	*Household frequency*	*Mean number of days*
Number of months sufficient food was available in the past year	40.00 % (88)	0.77	34.85 % (23)	0.83
Number of days household relied on less-preferred food in the past seven days	56.36 % (124)	1.05	53.03 % (35)	1.09
Number of days household had to limit the variety of foods eaten in the past seven days	54.09 % (119)	0.99	46.97 % (31)	1.03
Number of days household had to limit portions of food at mealtimes in the past seven days	55.25 % (121)	1.04	45.45 % (30)	1.06
Number of days household had to reduce the number of meals eaten per day in the past seven days	50.45 % (111)	0.86	43.08 % (28)	0.80
Number of days household had to restrict consumption by adults for small children to eat in the past seven days	40.00 % (88)	0.77	34.85 % (23)	0.83
Number of days household had to ask for food from friends/relatives in the past seven days	22.27 % (49)	0.39	15.15 % (10)	0.19
Number of days household had no food for the whole day in the past seven days	19.55 % (43)	0.29	9.09 % (6)	0.11

Table 4
Source of food.

Source of food	Participants (n = 220)		Non-participants(n = 66)	
	Number of households	Percentage	Number of households	Percentage
Own food production	110	50.00	25	37.88
Purchases only	2	0.45	6	9.09
Own food production and purchases	109	49.55	35	53.03
Total	***220***	***100***	***66***	***100***
Food from forests	109	49.55	45	68.18

4.2. Determinants of household participation in forest activities

The logit regression model was used to estimate the factors for household participation in forest activities, i.e., 1 = *Participant* and 0 = *Non-participant*, using the explanatory variables in Table 1. Tests on multicollinearity, heteroscedasticity and model specification errors were run, which found that none of these problems existed. Table 5 presents the marginal effects results of the logit regression.

As expected, households living further away from the forests had a lower probability of participating in forest activities. Similar results were yielded in previous studies (Fonta et al., 2011; Newton et al., 2016; Ogada, 2012; Sapkota and Odén, 2008), which showed that distance to

[1] Acres was used here because it is the common unit of measurement known by the households.

Table 5
Marginal effects results after logit regression.

Variable	dy/dx	Standard error	*p*-value
Education of household head	−0.0012	0.0067	0.853
Sex of household head	−0.0391	0.0571	0.493
Household size	−0.0073	0.0103	0.479
Age	0.0001	0.0015	0.927
Expenditure	6.13e-08	0.0097	0.830
Livestock ownership	0.0486	0.0510	0.341
Off-farm activities	−0.0763*	0.0456	0.094
Distance to the forest	−0.0018***	0.0007	0.007
Size of land held	0.0027	0.0031	0.379
Forest degradation awareness	0.0619	0.0437	0.157
Drought shock	0.0317	0.0208	0.128
Crop-pest shock	−0.0077	0.0058	0.182
Agricultural-output price shock	0.0017	0.0119	0.884
Loss-of-livestock shock	−0.0006	0.0081	0.937
Death or illness of a household member	0.0345***	0.0121	0.004

Note: *, ** and *** = 10 %, 5 % and 1 % levels of significance.

the forest was negatively related to participation in forest activities or forest dependence. Living close to forests enabled easy access to forest resources for example fuelwood and medicinal plants that support rural households' livelihoods. Households living closer to forests are more likely to use forest products (Ali and Rahut, 2018).

Household heads who engaged in off-farm activities – i.e., activities other than farming and forestry, such as shop owners and employees in the public or private sector – were found to have a lower probability of participating in forest activities, other explanatory variables being constant. Such findings were similar to Soe et al. (2019), Hussain et al. (2019). Furthermore, off-farm income was reportedly higher on average than both farm- and forest-related incomes in this study.

Households where a member had died or become ill had a higher probability of participating in forest activities. Some of these households resorted to extracting forest resources to earn emergency money by producing and selling charcoal, for example. Households also reported that it was quicker and easier to earn emergency money by participating in forest activities than by other means. Forests also became safety nets by providing households with forest food and income to purchase food during lean seasons. Similar findings were obtained by McSweeney (2004), Pattanayak and Sills (2001).

Even though engaging in off-farm activities could lead to earning higher incomes, as found here, participants were averse to the risk of starting new ventures or shifting to alternative activities. For many of those who were dependent on rural forests, the start-up capital required for setting up a new business like a local shop was not affordable. Furthermore, the lack of supportive infrastructure such as good roads, water and electricity that could encourage investment meant alternative sources of income were limited. Hence, these rural households remained largely dependent on forests for their subsistence, as a safety net, and as a way out of poverty.

4.3. The linkage between food security and forest use: a comparison between participants' and non-participants' food security outcomes

The PSM results of the household food-security outcomes between the participants and non-participants are presented in Table 6.

Nearest-neighbour matching and inverse-probability weights were also used for matching and showed similar results to the propensity score matching results shown in Table 6. The quality of matching was checked using the covariate balancing; the results showed that covariates were balanced and that there were no systematic differences in the covariates between participants and non-participants included in the matching analysis (see Fig. 1). Also, after applying PSM, the same number of treated and untreated households were maintained. The differences in food security outcomes between participants and non-participants were also tested using *t*-test means of difference approach and revealed significant differences for some food security outcomes

Table 6
Results of propensity score matching.

Food-security outcome variable	Participants vs Non-participants	
	ATT (Coefficient)	Standard error
Number of months sufficient food was available in the past year	−0.827***	0.294
Household experienced a food shortage in the past three years	0.250***	0.083
Household was worried about not having enough food in the past seven days	−0.045	0.079
Number of days household relied on less-preferred food in the past seven days	−0.136	0.175
Number of days household had to limit the variety of foods eaten in the past seven days	0.041	0.165
Number of days household had to limit portions of food at mealtimes in the past seven days	0.027	0.181
Number of days household had to reduce the number of meals eaten per day in the past seven days	0.027	0.206
Number of days household had to restrict consumption by adults for small children to eat in the past seven days	0.255	0.175
Number of days household had to ask for food or rely on food from friends/relatives in the past seven days	0.273**	0.123
Number of days household had no food for the whole day in the past seven days	0.223**	0.112

Note: *ATT* = average treatment effect on the treated; *, ** and *** = 10 %, 5 % and 1 % levels of significance.

between the two groups; these are similar to the PSM results, and hence not presented here.

Table 6 illustrates that, compared with non-participants with the same socioeconomic characteristics, participants had fewer months of sufficient available food in the year preceding the interview. This result suggests that participants had lower stocks of food as a secure supply for the year than non-participants had. Participants also produced relatively less food for the prior year in question; for example, they harvested an average of 530 kg of maize, the main staple, compared with 567 kg by non-participants as reported in the survey.

Table 6 also reveals that the probability of having experienced a food shortage over the three years prior to the interview was higher for participants than for non-participants with the same socioeconomic characteristics. Again, the result implies that participants were less food-secure than non-participants. Notably, although both participants and non-participants faced similar risk factors, such as crop pests and weather-related shocks like drought and floods, the impact of these factors was less severe on non-participants because their food production was higher than that of participants and participants therefore experienced more shortages in household food stocks.

Further revelations from the Table 6 results are that, on average, participants experienced more days of having no food for the whole day in the seven days prior to the interview than non-participants with comparable characteristics did. Correspondingly, participants had a greater number of days of asking for food or relying on food from friends/relatives in the prior seven-day period than the non-participants. These results all point to participants being significantly less food-secure than their counterparts. Moreover, although households in the surveyed areas were farmers producing food for own consumption, households sometimes had to purchase food; indeed, the majority both produce and buy food (see Table 4). Apart from food production, therefore, monetary income matters when it comes to ensuring food security.

Overall, the empirical results suggest that participants were less food secure than non-participants with similar socioeconomic characteristics, in line with several previous studies. So, despite the role played by forests for their livelihoods including food security, participants were food insecure. These results are similar to Abadi (2017) who found that

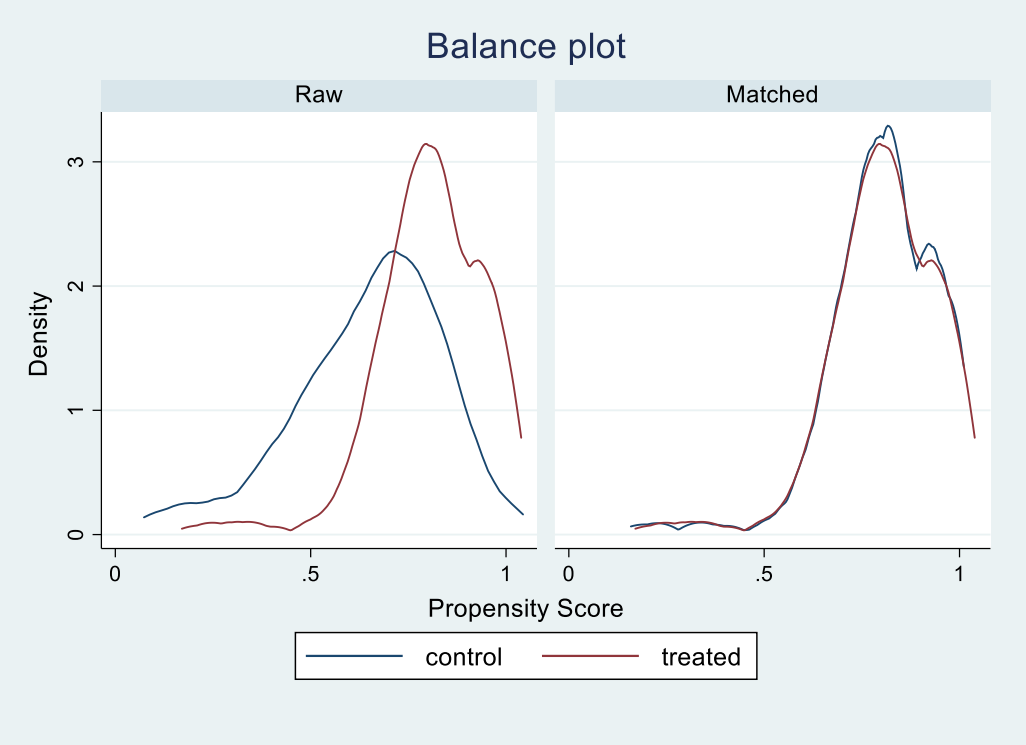

Fig. 1. Density function showing the distribution balance before(raw) and after propensity score matching.

forests offer some safety, but that those who participated in forest resource extraction were relatively poor, and are in contrast to e.g. Rahut et al. (2015) study which found that forests reduce poverty and enhance food security. The difference in results between the latter study and current study may be due to the differences in study context.

5. Conclusion and policy implications

This study aimed at analysing the linkage between forest use and household food security in the rural areas of Tanzania's Shinyanga Region. Although the rural household heads were all farmers, the survey showed that most of them also participated in forest-based livelihood activities. This confirms that rural household farmers depend on such activities to survive, implying there is a strong linkage between forests and household food security.

There are three potential roles that forests are hypothesized to play in supporting rural livelihoods in developing countries – as a safety net, as a coping strategy, and as a source of poverty reduction. In Shinyanga Region, the first two are clearly the most important. The empirical results showed that distance to the forest, off-farm activities and the illness or death of a household member significantly influenced the household's participation in forest activities. Thus, living nearby forests was certain to raise the probability of participation in such activities. This finding supports many earlier studies on forest dependence in developing countries and underlines the conclusion that forest-adjacent households are indeed the primary drivers of forest use. Furthermore, households who had experienced the illness or death of a member more frequently participated in forest activities, confirming that forests serve as a safety net during crises. So, forest activities potentially provide some alleviation to their food insecurity challenges.

Conversely, household heads with alternative sources of income from off-farm activities had a lower probability of participation. Thus, to diminish their reliance on forests, households should diversify their means of obtaining an income, and should be supported by the development of infrastructure that could attract investment to rural areas. However, such diversification can only be achieved by enhancing unskilled or semi-skilled labour through education and training. Involvement in off-farm activities to earn a cash income also reduces the pressure exerted on forests by resource extraction.

The PSM results revealed that there were significant differences in food security between participants and comparable non-participants for some of the food security indicators. Participants in forest activities were less food-secure than their non-participating counterparts in terms of having experienced food shortages in the prior three years, the number of days that a household had to ask for food or rely on food from relatives/friends, the number of months of enough food availability, and the number of days households had no food for the whole day. If one cuts across these four significant food-security outcomes, one sees that participants lacked sufficient food stocks as well as adequate income to support their food security. The conclusion here is that food security is a grave concern amongst forest-dependent rural households. This study also supports the stance that participation in forest activities leads to a poverty trap because participants were less food-secure on average than non-participants with comparable characteristics. Also, the participants took part in low return forest related activities that did not uplift them out of poverty. Government policy measures should therefore aim to combat food insecurity by enhancing income options, food storage facilities and farming methods that increase food production and improve agricultural productivity. Nevertheless, forests are likely to remain important for food security for rural households in Shinyanga Region for a long time to come, and the region's forests need to be conserved to ensure the continued well-being of the households that depend on them.

CRediT authorship contribution statement

Matilda Stanslaus Ntiyakunze: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jesper Stage:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

Abadi, N., 2017. Natural insurance, conservation of forests and poverty reduction in the semi-arid Region of Tigray, Northern Ethiopia. Unpublished PhD Thesis, University College Cork, Cork, Ireland.

Ali, A., Rahut, D.B., 2018. Forest-based livelihoods, income, and poverty: empirical evidence from the Himalayan region of rural Pakistan. J. Rural. Stud. 57, 44–54. https://doi.org/10.1016/j.jrurstud.2017.10.001.

Angelsen, A., Wunder, S., 2003. Exploring the forest–poverty link: key concepts, issues and research implications. CIFOR Occasional Paper 40. Center for International Forestry Research, Bogor.

Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N.J., Bauch, S., Börner, J., Smith-Hall, C., Wunder, S., 2014. Environmental income and rural livelihoods: a global-comparative analysis. World Dev. 64, S12–S28. https://doi.org/10.1016/j.worlddev.2014.03.006.

Arnold, M., Powell, B., Shanley, P., Sunderland, T.C.H., 2011. Editorial: forests, biodiversity, and food security. Int. For. Rev. 13 (3), 259–264.

Austin, P.C., 2011. An introduction to propensity score methods for reducing the effects of confounding in observational studies. Multivar. Behav. Res. 46 (3), 399–424, 10.1080%2F00273171.2011.568786.

Baffes, J., Kshirsagar, V., Mitchell, D., 2019. What drives local food prices? Evidence from the Tanzanian Maize Market. World Bank. Econ. Rev. 33 (1), 160–184. https://doi.org/10.1093/wber/lhx008.

Broegaard, R.B., Rasmussen, L.V., Dawson, N., Mertz, O., Vongvisouk, T., Grogan, K., 2017. Wild food collection and nutrition under commercial agriculture expansion in agriculture-forest landscapes. For. Policy. Econ. 84, 92–101.

Chhetri, B.B.K., Johnsen, F.H., Konoshima, M., Yoshimoto, A., 2013. Community forestry in the hills of Nepal: determinants of user participation in forest management. For. Policy. Econ. 30, 6–13.

Chukwuone, N.A., Okeke, C.A., 2012. Can non-wood forest products be used in promoting household food security? Evidence from savannah and rain forest regions of Southern Nigeria. For. Policy. Econ. 25, 1–9.

Cook, T.D., 2015. Quasi-experimental design. Wiley Encycl. Manag. 1–2. https://doi.org/10.1002/9781118785317.

Cooper, M., Zvoleff, A., Gonzalez-Roglich, M., Tusiime, F., Musumba, M., Noon, M., Alele, P., Nyiratuza, M., 2018. Geographic factors predict wild food and nonfood NTFP collection by households across four African countries. For. Policy. Econ. 96, 38–53.

Dokken, T., Angelsen, A., 2015. Forest reliance across poverty groups in Tanzania. Ecol. Econ. 117, 203–2011. https://doi.org/10.1016/j.ecolecon.2015.06.006.

Falconer, J., Arnold, J.E.M., 1991. Household Food Security and Forestry: An Analysis of Socio-Economic Issues. FAO, Rome.

FAO/Food and Agriculture Organization of the United Nations, 2011. Forests For Improved Nutrition and Food Security. FAO, Rome.

FAO/Food and Agriculture Organization of the United Nations, 2016. Integrated Policy for Forests, Food Security and Sustainable Livelihoods: Lessons from the Republic of Korea. FAO, Rome, pp. 21–52.

FAO/Food and Agriculture Organization of the United Nations, 2020. Global Forest Resources Assessment 2020: Report – United Republic of Tanzania. FAO, Rome.

FAO and MNRT/Food and Agriculture Organization of the United Nations and Ministry of Natural Resources and Tourism, United Republic of Tanzania, 2020. Training Manual on Forests and Trees For Food Security and Nutrition. FAO, Rome. https://doi.org/10.4060/ca7249en.

FAO, IFAD, UNICEF, WFP and WHO, 2020. The State of Food Security and Nutrition in the World 2020. Transforming Food Systems For Affordable Healthy Diets. FAO, Rome. https://doi.org/10.4060/ca9692en.

Fisher, M., 2004. Household welfare and forest dependence in Southern Malawi. Environ. Dev. Econ. 9 (2), 135–154. https://doi.org/10.1017/S1355770×03001219.

Fisher, M., Chaudhury, M., McCusker, B., 2010. Do forests help rural households adapt to climate variability? Evidence from Southern Malawi. World Dev. 38 (9), 1241–1250.

Fonta, M.W., Ichoku, H.E., Ayuk, E., 2011. The distributional impacts of forest income on household welfare in rural Nigeria. J. Econ. Sustain. Dev. 2 (2), 1–13.

Garekae, H., Thakadu, O.T., Lepetu, J., 2017. Socio-economic factors influencing household forest dependency in Chobe enclave, Botswana. Ecol. Process. 6, 40. Article.

Hade, E.M., Lu, B., 2014. Bias associated with using the estimated propensity score as a regression covariate. Stat. Med. 33 (1), 74–87. https://doi.org/10.1002/sim.5884.

Hall, C.M., Rasmussen, L.V., Powell, B., Olesen, R.S., 2022. Deforestation reduces fruit and vegetable consumption in rural Tanzania. Environ. Sci. (Ruse) 119 (10), e2112063119. https://doi.org/10.1073/pnas.2112063119.

Haule, T.R., Mwamfupe, A., 2016. The implications of non-timber forest products' access by-laws on household food security in semi-arid zones of Iringa District, Tanzania. J. Geograph. Assoc. Tanzania 39 (1), 92–117.

HLPE/High-Level Panel of Experts. 2017. Sustainable forestry for food security and nutrition. A Report By the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

Hussain, J., Zhou, K., Akbar, M., Khan, M.Z., Raza, G., Ali, S., Hussain, A., Abbas, Q., Khan, G., Khan, M., Abbas, H., Iqbal, S., Ghulam, A., 2019. Dependence of rural livelihoods on forest resources in Naltar Valley, a dry temperate mountainous region, Pakistan. Glob. Ecol. Conserv. 20, e00765. Article.

IPC, 2020. Tanzania, Nearly 1 Million People Are Severely Food Insecure. IPC Acute Food Insecurity Analysis. IPC (Integrated Food Security Phase Classification). FAO.

Kabubo-Mariara, J., Gachoki, C., 2008. Forest dependence and household welfare: empirical evidence from Kenya. CEEPA Discussion Paper No. 41. Centre for Environmental Economics and Policy in Africa, University of Pretoria, Pretoria.

Kahimba, F.C., Sife, A.S., Maliondo, S.M.S., Mpeta, E.J., Olson, J., 2015. Climate change and food security in Tanzania: analysis of current knowledge and research gaps. Tanzania J. Agric. Sci. 14 (1), 21–33.

Karki, R., Shrestha, K.K., Ojha, H., Paudel, N., Khatri, D.B., Nuberg, I., Adhikary, A., 2017. From forests to food security: pathways in Nepal's community forestry. Small-Scale For. 17 (1), 89–104. https://doi.org/10.1007/s11842-017-9377-y.

Kilama, B., 2016. Where Are the Poor: Region and District Poverty Estimates for Tanzania, 2012. PowerPoint presentation. Policy Research for Development (REPOA), Dar es Salaam. Available at http://www.tzdpg.or.tz/fileadmin/documents/external/national_development_frameworks/Poverty_Mapping-_PED_June_2016_.pdf. last accessed 10 May 2021.

Lepetu, J., Alavalapati, J.R.R., Nair, P.R., 2009. Forest dependency and its implication for protected areas management: a case study from Kasane Forest Reserve, Botswana. Int. J. Environ. Res. 3 (4), 525–536.

Maciejewski, M.L., 2018. Quasi-experimental design. Biostat. Epidemiol. 1–10. https://doi.org/10.1080/24709360.2018.14.

Malunguja, G.K., Devi, A., 2020. Current trend on plant species diversity and productivity potential among community conserved ngitili subjected to grazing pressure in Kishapu District, Tanzania. Int. J. Sci. Res. Eng. Dev. 3 (2), 593–618.

McSweeney, K., 2004. Forest product sale as natural insurance: the effects of household characteristics and the nature of shock in eastern Honduras. Soc. Nat. Resour. 17 (2004), 39–56. https://doi.org/10.1080/08941920490247245.

Milbank, C., 2023. Associating dietary quality and forest cover in India. For. Policy. Econ. 156, 103055.

Mulenga, B.P., Hadunka, P., Richardson, R.B., 2017. Rural households' participation in charcoal production in Zambia: does agricultural productivity play a role? J. For. Econ. 26 (1), 56–62.

NBS/National Bureau of Statistics, 2014. National Panel Survey Wave 3, 2012-2013. National Bureau of Statistics, Ministry of Finance, Dar es Salaam, Tanzania.

NBS (National Bureau of Statistics), 2018. Tanzania Mainland household budget survey 2017/18. Retrieved on 06th September 2024 from https://www.nbs.go.tz/nbs/takwimu/hbs/2017_18_HBS_Key_Indicators_Report_Engl.pdf.

Newton, P., Miller, D.C., Byenkya, M.A.A., Agrawal, A., 2016. Who are forest-dependent people? A taxonomy to aid livelihood and land use decision-making in forested regions. Land. Use Policy 57, 388–395. https://doi.org/10.1016/j.landusepol.2016.05.032.

Ntiyakunze, M.S., Stage, J., 2022. Forest dependence in Tanzania: analysis of the determinants of perceived forest dependence. Trees. For. People 8, 100277.

Ogada, M.J., 2012. Forest management decentralization in Kenya: effects on household farm forestry decisions in Kakamega. Paper presented at. In: Proceedings of the International Association of Agricultural Economists (IAAE) Triennial Conference. Foz do Iguacu, Brazil, 18–24 August 2012.

Pandey, R., 2010. Heterogeneity in household characteristics, forest resource utilization and sustainability in [sic] hills of Uttaranchal: a case study. Silva Lusit. 18 (1), 75–84.

Pattanayak, S.K., Sills, E.O., 2001. Do tropical forests provide natural insurance? The microeconomics of non-timber forest product collection in the Brazilian Amazon. Land. Econ. 77 (4), 595–612. https://doi.org/10.2307/3146943.

Putri, A.A.D., Kweka, D.L., 2015. Pilot project on community-based REDD mechanisms for sustainable forest management in semiarid areas: the case of ngitilis in the Shinyanga Region, Tanzania. CIFOR, REDD+ON THE GROUND, chapter 16, Case Report Tanzania..

Rahut, D.B., Ali, A., Beherea, B., 2015. Household participation and effects of community forest management on income and poverty levels: empirical evidence from Bhutan. For. Policy. Econ. 61, 20–29. https://doi.org/10.1016/j.forpol.2015.06.006.

Randell, H., Gray, C., Shayo, E.H., 2022. Climatic conditions and household food security: evidence from Tanzania. Food Policy 112, 102362. https://doi.org/10.1016/j.foodpol.2022.102362.

Rashid, F.N., Sesabo, J.K., Lihawa, R.M., Mkuna, E., 2024. Determinants of household food expenditure in Tanzania: implications on food security. *Agric. Food Secur.* 13 13 (2024). https://doi.org/10.1186/s40066-023-00462-0.

Sapkota, I.P., Odén, P.C., 2008. Household characteristics and dependency on community forests in Terai of Nepal. Int. J. Soc. For. 1 (2), 123–144.

Soe, K.T., Yeo-Chang, Y., 2019. Livelihood dependency on non-timber forest products: implications for REDD+. Forests 10 (5), 427. https://doi.org/10.3390/f10050427.

Sunderland, T., Powell, B., Ickowitz, A., Foli, S., Pinedo-Vasquez, M., Nasi, R., Padoch, C., 2013. Food security and nutrition: the role of forests. CIFOR Discussion Paper No. 1. Center for International Forestry Research, Bogor.

URT/United Republic of Tanzania, 2017. *Tanzania Human Development Report: Social policy in the context of economic transformation*. Economic and Social Research Foundation. In: the United Republic of Tanzania, Dar es Salaam. United Nations

Development Programme – Tanzania Office and Government of the United Republic of Tanzania, Dar es Salaam.
Wainaina, P., Minang, P.A., Nzyoka, J., Duguma, L., Temu, E., Manda, L., 2021. Incentives for landscape restoration: lessons from Shinyanga, Tanzania. J. Environ. Manage. 280, 111831.
World Food Summit 1996, Rome declaration on world food security.
Wunder, S., Börner, J., Shively, G., Wyman, M., 2014. Safety nets, gap filling and forests: a global-comparative perspective. World Dev. 64 (1), S29–S42. https://doi.org/10.1016/j.worlddev.2014.03.005.