Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Transforming Forest Dependence into Sustainable Livelihood Pathways: Evidence from Community Forest Associations in Kenya

Castro N. Gichuki

cgichuki@strathmore.edu

Strathmore University Business School-Strathmore Agri-Food Innovation Centre

Charles K Wambu

Cooperative University- School of cooperative and community health development

Research Article

Keywords: Community Forest Associations, East Africa, Endogenous switching regression, Household income, Plantation Establishment and Livelihood Improvement Scheme (PELIS), Treatment effects

Posted Date: November 24th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11729294/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Transforming Forest Dependence into Sustainable Livelihood Pathways: Evidence from Community Forest Associations in Kenya

Castro N. Gichuki[1]* . Charles K Wambu[2]

[1]Strathmore University Business School-Strathmore Agri-Food Innovation Centre, Nairobi, Kenya.

[2]Cooperative University- School of cooperative and community health development, Nairobi, Kenya.

*Corresponding authors: Castro N. Gichuki; Email: ngumbucg@gmail.com ; Phone number: 0708868969

Acknowledgments

The authors express their gratitude to the field enumerators, local community leaders, the Kenya Forest Service (KFS), and the participating Community Forest Associations (CFAs) for their support during field data collection.

ABSTRACT

A key challenge for developing countries is to reconcile forest conservation with the need of forest-dependent communities to earn a living. Participatory forest management, implemented in Kenya through Community Forest Associations (CFAs), is promoted as a way to improve forest governance while supporting rural livelihoods. This study examines whether CFA participation is associated with household income and forest-resource income among forest-adjacent households. Using survey data from 2,513 households, of which 1,904 had complete observations, we apply an endogenous switching regression (ESR) model to account for selection associated with voluntary participation and to estimate counterfactual outcomes for members and non-members. CFA participation is associated mainly with institutional and resource-access factors, including participation in the Plantation Establishment and Livelihood Improvement Scheme (PELIS), forest grazing group membership, access to credit, and proximity to roads. Estimated treatment effects suggest that CFA membership is associated with 22.3% higher household income and 7.5% higher forest-resource income than the counterfactual of non-participation. These estimates are imprecise, statistically insignificant at conventional levels, and diagnostic tests fail to detect selection on unobservables, so they are best interpreted as conditional associations rather than causal effects. The findings suggest that CFAs might be able to contribute to livelihood support if participation is coupled with tangible incentives and supportive complementary institutions.Enhanced role for participatory forest management in sustainable rural livelihoods can be achieved by strengthening CFA governance, expanding PELIS and forest-based enterprises and improving market and service linkages.

KEYWORDS: Community Forest Associations; East Africa; Endogenous switching regression; Household income; Plantation Establishment and Livelihood Improvement Scheme (PELIS); Treatment effects.

1 Introduction

One of the main challenges of modern rural development is to harmonise sustainable forest management with the enhancement of the livelihoods of the forest-dependent communities. Forest ecosystems provide essential environmental services such as biodiversity conservation, climate regulation, watershed protection and carbon storage and at the same time support millions of rural households with food, energy, employment and income generating opportunities (Chidumayo and Gumbo 2010; FAO 2020; Githiomi and Oduor 2012). Forests are an important component of livelihood portfolios for many households in developing countries, providing resources that buffer against agricultural uncertainty, market failures, and climate-related shocks (Angelsen et al. 2014; Shackleton et al. 2001). However, increasing pressure on forest ecosystems has intensified debates on how conservation objectives can be achieved without undermining the welfare of communities whose livelihoods are closely linked to forest resources.

A key unresolved issue in forest livelihood research is whether dependence on forest resources is part of a sustainable livelihood transformation or a sign of continued vulnerability (Angelsen and Wunder 2003). Forest resources can help households to be more resilient by diversifying their income portfolios through activities such as commercializing non-timber forest products, beekeeping, ecotourism, tree nurseries and forest-based enterprises. Diversification is an important mechanism within the sustainable livelihood framework for households to manage risks, overcome seasonal income constraints and improve welfare outcomes (Barrett et al. 2001, Ellis 2000). The opposite is true, since a high dependence on forest extraction may indicate a lack of livelihood options, with households involved in low-return activities due to limited access to markets, capital and productive opportunities (Angelsen and Wunder 2003; Wunder et al. 2014). Understanding the conditions under which forest dependence becomes a

pathway for livelihood improvement rather than a poverty trap (Carter and Barrett 2013) remains an important empirical question.

In response to these competing objectives, forest governance has progressively shifted from centralised protection approaches towards participatory and community-based management models. PFM approaches are founded on the belief that involving local communities in decision-making, benefit sharing and resource governance fosters incentives for sustainable conservation and at the same time supports rural development (Agrawal and Gibson 1999; Chirenje et al. 2013; Nath and Inoue 2010).Community institutions can enhance collective action, improve access to information and training, support resource management and foster innovation in forest-based livelihoods.

Kenya provides an important case for examining these dynamics because participatory forest governance has been formally institutionalised through Community Forest Associations (CFAs). CFAs represent legally recognised community organisations that collaborate with the Kenya Forest Service (KFS) in forest conservation, restoration, and regulated resource use (Koech et al. 2009). Beyond conservation, CFAs are expected to support livelihood diversification through activities such as commercial tree nurseries, sustainable harvesting of non-timber forest products, value addition, ecotourism, and other nature-based enterprises (Githiomi and Oduor 2012). Therefore, CFAs represent more than conservation institutions; they provide a potential mechanism for linking environmental sustainability with inclusive rural economic development.

Despite the growing emphasis on community-based forest governance, evidence of livelihood impacts of CFAs remain mixed. Some studies show that participatory approaches improve

conservation outcomes and provide opportunities for livelihoods while others report challenges associated with weak governance capacity, unequal distribution of benefits, elite capture and limited economic benefits to participating households (Mogoi et al. 2012; Mutune and Lund 2016). These contrasting findings raise questions about whether community forestry institutions effectively transform forest-dependent livelihoods or primarily regulate continued access to forest resources.

There is a growing consensus that participatory forest management is a potential way of reconciling conservation and rural development objectives. But there are three important gaps in knowledge. First, much of the existing literature has focused on institutional performance, governance structures and ecological outcomes of community forestry, with less attention to whether participation generates measurable livelihood benefits for forest-adjacent households. In particular, limited empirical evidence exists on whether CFAs improve household welfare by enhancing the productive use of forest resources and supporting livelihood opportunities.

Second, the existing studies do not understand well the pathways by which community forest institutions affect household livelihood outcomes. Participation in CFAs does not automatically translate into economic benefits. Rather, the impacts on livelihoods depend on the extent to which institutions enhance access to knowledge, conservation training, opportunities for resource use, collective action platforms, and complementary livelihood support. Understanding these pathways is important for determining whether participatory forest governance can simultaneously support conservation goals and rural economic resilience.

Third, estimating the livelihood contribution of CFAs remains methodologically challenging because participation is voluntary. Households that become CFA members may differ systematically from non-members due to differences in resource access, institutional networks,

experience, motivation, and ability to engage in collective action. Simple comparisons between participating and non-participating households may therefore produce biassed estimates of the true contribution of CFA membership.

The study seeks to fill these gaps by investigating the effects of participation in CFAs on household livelihood outcomes in forest adjacent communities in Kenya. In particular, the study investigates the effects of being a member of CFA on total household income and income from forest resources and the institutional factors associated with these effects. Using household survey data from 2,513 households (1,904 with complete observations) across seven forest landscapes, the study applies an Endogenous Switching Regression (ESR) framework to control for selection bias associated with voluntary participation and estimate counterfactual livelihood outcomes for CFA members and non-members.

The study contributes three ways to the literature on forest governance and rural livelihoods. First, it contributes empirical evidence on the role of CFAs as institutions of conservation and as platforms for improving livelihood outcomes. Secondly, it adds to the understanding of the mechanisms connecting participatory forest governance and household welfare by examining the role of conservation training, participation in the Plantation Establishment and Livelihood Improvement Scheme (PELIS), collective resource-management groups and institutional access. Third, it strengthens the methodological evidence base by applying a counterfactual approach that accounts for observable and unobservable differences between CFA participants and non-participants.

The study draws on evidence from Kenya's participatory forest governance system and provides insights for the design of community-based conservation models that integrate

sustainable resource management and rural livelihood improvement. The findings are particularly relevant for policies seeking to strengthen CFAs as institutions that support both ecosystem conservation and the economic resilience of forest-adjacent communities.

The remainder of the paper is organised as follows. Section 1.1 presents the institutional context of participatory forest management in Kenya and the conceptual pathways linking CFA participation to livelihood outcomes. Section 2 describes the data and empirical approach. Section 3 presents the empirical results, Section 4 discusses them, and Section 5 concludes with implications for community-based forest governance and rural development policy.

1.1 Conceptual and institutional context

This section presents the institutional context for participatory forest management in Kenya and the conceptual pathways between participation in the CFA and livelihood outcomes. CFAs are regulated by the Forest Conservation and Management Act which provided for formal participation of the community in forest governance through joint management agreements with the Kenya Forest Service. Through these arrangements, CFAs participate in forest protection, restoration, and regulated resource use and are expected to facilitate livelihood opportunities linked to forest resources and associated enterprises. National assessments of Kenya's forest resources and environment document continuing pressure on forest ecosystems (Kenya Forest Service 2021).

Within a sustainable livelihoods perspective (Bebbington, 1999; Ellis, 2000), CFAs may influence household outcomes through several pathways: (i) improving access to forest land and products under regulated schemes such as PELIS; (ii) providing platforms for collective action and forest-user groups; (iii) enhancing access to conservation training, extension, and information; and (iv) connecting households to complementary support such as credit, markets,

and contracts for forest-based enterprises. These mechanisms can shape both forest-resource income and broader income diversification. The pathways are summarized in Fig. 1.

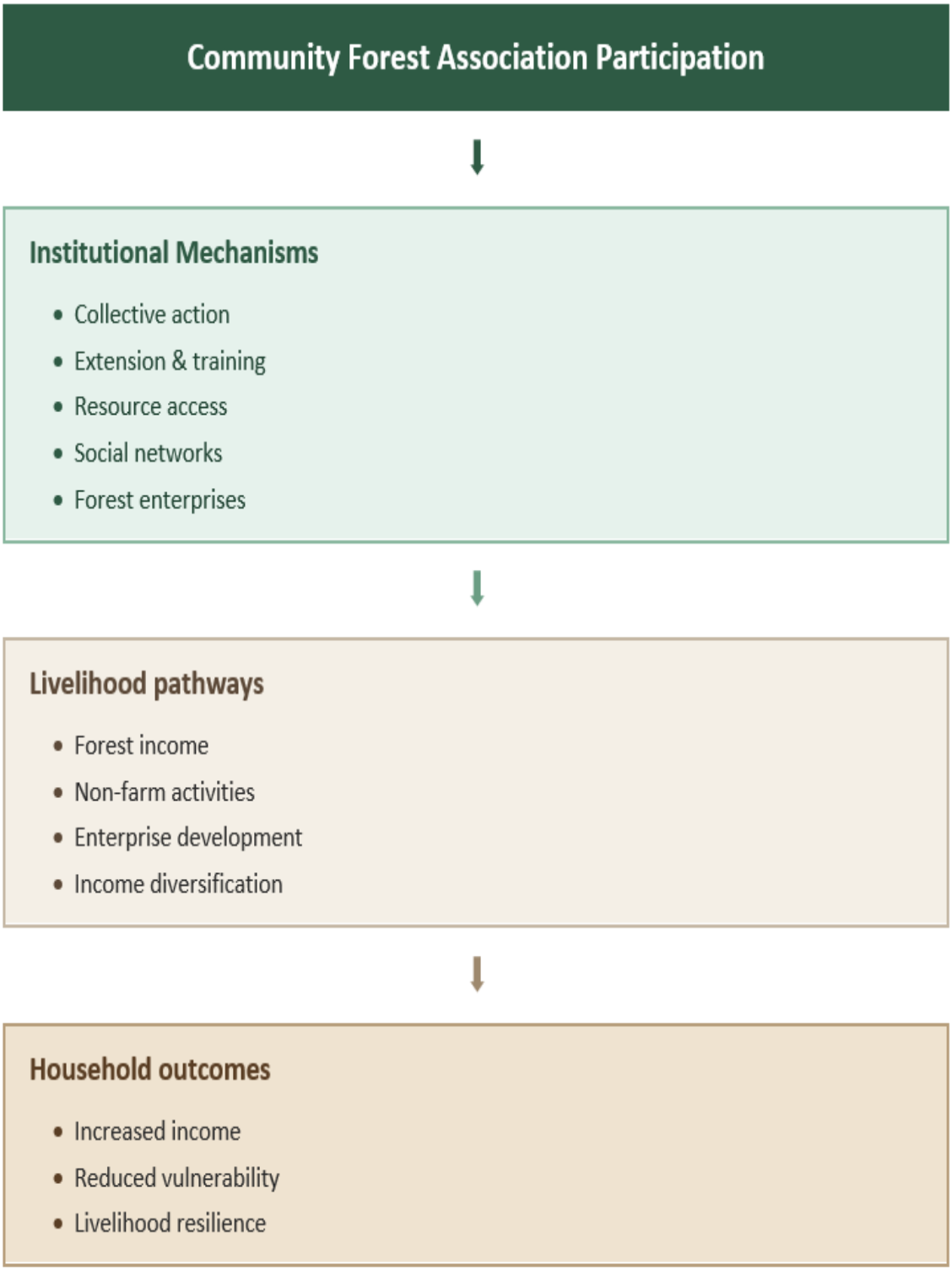

Fig. 1 Conceptual framework linking CFA participation, livelihood pathways and household outcomes.

2 Materials and methods

2.1 Study area and data sources

This study used household-level survey data collected from forest-adjacent communities participating in Kenya's participatory forest management system. The study focused on communities located around seven forest blocks where CFAs have been established as institutional mechanisms for promoting sustainable forest management and livelihood development.

The selected forest landscapes included Kabaru Forest (Nyeri County), Kiera Hill Forest (Tharaka Nithi County), Iveti/Kibaoni Forest (Machakos County), Londiani Forest (Kericho County), Nyangweta/Ritumbe Forest (Kisii County), Koibatek Forest (Baringo County), and Ol'Bolosat Forest (Nyandarua County). These forest blocks were selected because they represent diverse ecological and livelihood systems, including highland forest ecosystems, semi-arid landscapes, agricultural communities, and mixed crop-livestock production systems.

Study sites were chosen to capture heterogeneity in forest governance arrangements, livelihood strategies and household dependence on forest resources. The sampled landscapes include plantation and natural forest, gazetted and community managed forest areas and areas with varying agricultural potentials and resource dependencies. This diversity provided an opportunity to assess how participation in CFAs influences household livelihood strategies across different socio-ecological contexts.

The study focused on households living adjacent to forest ecosystems including CFA members engaged in forest management activities and similar non-members in the same communities. Data were collected on household demographics, livelihood activities, forest resource use,

income sources, participation in CFA activities, access to services and socio-economic characteristics influencing livelihood decision making.

2.2 Sampling strategy and data collection

Households for the study were selected using a multi-stage sampling approach. In the first stage, the seven forest landscapes were clustered into two geographical clusters, namely the Central region which comprised Machakos, Tharaka Nithi, Nyandarua and Nyeri counties and the Western region which comprised Baringo, Kericho and Kisii counties. This clustering captured differences in agro-ecological conditions, livelihood systems, and forest management contexts.

The required household sample size was estimated using the standard sample size determination approach for population proportions: $n = (Z^2p(1-p))/d^2$, where n represents the required sample size, Z is the standard normal value corresponding to the desired confidence level, p represents the expected proportion of households with the characteristic of interest, and d represents the acceptable margin of error. The study adopted the following parameters: confidence level of 95% ($Z = 1.96$), estimated population proportion of 0.30 and precision level of 5%. After adjusting for potential non-response, the minimum required sample size was estimated at approximately 359 households per county, resulting in a final sample of 2,513 households across the seven counties.

Within each county, forest-adjacent communities were selected within approximately a five-kilometer radius of the targeted forest blocks. Locations, sub-locations and villages were identified based on proximity to forest resources and presence of CFA structures. We selected households that had participated in the CFAs and households that had not participated in the

CFAs. This allowed us to compare the livelihood outcomes of households that participated in participatory forest governance and households that did not.

A digital data collection platform was used to administer a structured household questionnaire. The survey captured information on household characteristics, land and productive assets, income-generating activities, forest resource utilization, participation in forest-related institutions, access to extension and training services, and livelihood diversification strategies. During the data collection, the quality of data was ensured through enumerator training, pre-testing of questionnaire, field supervision and digital validation procedures. The final dataset consisted of 1,904 of the 2,513 surveyed households with complete observations and provided the empirical basis for assessing the contribution of CFA participation to livelihood diversification outcomes.

2.3 Empirical specification and estimation strategy

The issue of potential selection bias due to voluntary participation needs to be addressed to estimate the effect of CFA participation on household livelihood outcomes. Households join CFAs for expected benefits such as access to forest resources, training, opportunities for collective action and livelihood support. However, CFA participants may differ systematically from non-participants in observable characteristics such as education, assets and institutional access, and unobservable characteristics such as motivation, entrepreneurial ability, risk preferences and environmental awareness. Ignoring these differences may generate biased estimates of the effect of CFA participation on livelihood outcomes (Heckman 1979).

This is addressed by using the Endogenous Switching Regression (ESR) model in the study. ESR is suitable for evaluating interventions where participation is self-selected because it jointly estimates the participation decision and separate livelihood outcome equations under

participation and non-participation regimes (Abdulai and Huffman 2014; Lokshin and Sajaia 2004).

2.3.1 CFA participation decision model

Following the random utility framework, households are assumed to participate in CFAs when the expected benefits from participation exceed those from non-participation. Let C_i^* represent the unobserved latent utility difference associated with CFA participation. The selection equation is specified as:

$$\boldsymbol{C_i^* = Z_i\alpha + u_i} \quad (1)$$

where Z_i represents household, institutional, and location characteristics influencing CFA participation, α represents parameters to be estimated, and $u_i$is the random error term.

The observed CFA participation decision is defined as:

$$\boldsymbol{C_i = \begin{cases} 1, & if\ C_i^* > 0 \\ 0 & if\ C_i^* \leq 0 \end{cases}} \quad (2)$$

Where (C_i=1) represents households participating in CFAs and (C_i=0) represents non-participating households.

The probability of CFA participation is estimated using a probit specification:

$$\boldsymbol{Pr(C_i = 1|Z_i) = \phi(Z_i\alpha)} \quad (3)$$

Where $\boldsymbol{\phi(Z_i\alpha)}$ represents the cumulative distribution function of the standard normal distribution.

2.3.2 Livelihood outcome equations

Following the participation decision, households are observed under two alternative regimes: CFA participation and non-participation. The livelihood outcome equations are specified as:

Regime 1: CFA participants

$$\boldsymbol{Y_{1i} = X_{1i}\beta_1 + \varepsilon_{1i}, \quad if\ C_i = 1} \quad (4a)$$

Regime 2: CFA non-participants

$$\mathbf{Y_{0i}} = \mathbf{X_{0i}}\boldsymbol{\beta_0} + \boldsymbol{\varepsilon_{0i}}, \quad \boldsymbol{if}\ \mathbf{C_i} = \mathbf{0} \quad (4b)$$

where (Y_i) represents household livelihood outcomes, including household income, forest-related income, and income diversification. (X_i) represents household demographic characteristics, productive assets, institutional variables, and access-related factors. The coefficients (β_1) and (β_0) capture the determinants of livelihood outcomes under CFA participation and non-participation regimes, respectively.

2.3.3 Accounting for selection bias

The ESR framework accounts for possible correlation between unobservable factors affecting CFA participation and those affecting livelihood outcomes. The error terms from the selection and outcome equations are assumed to follow a trivariate normal distribution:

$$(\boldsymbol{u_i}, \boldsymbol{\varepsilon_{1i}}, \boldsymbol{\varepsilon_{0i}}) \sim \mathbf{N}(\mathbf{0}, \boldsymbol{\Sigma}) \quad (5)$$

with covariance matrix:

$$\boldsymbol{\Sigma} = \begin{bmatrix} \boldsymbol{\sigma_u^2} & \boldsymbol{\sigma_{u1}} & \boldsymbol{\sigma_{u0}} \\ \boldsymbol{\sigma_{u1}} & \boldsymbol{\sigma_1^2} & . \\ \boldsymbol{\sigma_{u0}} & . & \boldsymbol{\sigma_0^2} \end{bmatrix} \quad (6)$$

The correlation between the selection equation and the outcome equations is measured as:

$$\boldsymbol{\rho 1} = \frac{\boldsymbol{\sigma_{u1}}}{\boldsymbol{\sigma_u \sigma_1}} \quad (7a)$$

for CFA participants, and:

$$\boldsymbol{\rho 0} = \frac{\boldsymbol{\sigma_{u0}}}{\boldsymbol{\sigma_u \sigma_0}} \quad (7b)$$

for non-participants.

If ($\rho 1$) or ($\rho 0$) is significantly different from zero, it confirms the presence of selection bias and validates the use of the ESR approach (Lokshin & Sajaia, 2004).

The ESR model was estimated using Full Information Maximum Likelihood (FIML), which simultaneously estimates the selection and outcome equations to obtain consistent and efficient parameters.

2.3.4 Estimation of counterfactual outcomes and treatment effects

A major advantage of the ESR approach is that it estimates both observed and counterfactual livelihood outcomes. The expected livelihood outcome for CFA participants is expressed as:

$$\mathbf{E(Y_{1i}|C_i = 1) = X_{1i}\beta_1 + \sigma_{u1}\lambda_1} \quad (8)$$

The expected outcome CFA participants would have achieved had they not participated is:

$$\mathbf{E(Y_{0i}|C_i = 1) = X_{1i}\beta_0 + \sigma_{u0}\lambda_1} \quad (9)$$

Similarly, the expected livelihood outcome for non-participants is:

$$\mathbf{E(Y_{0i}|C_i = 0) = X_{0i}\beta_0 + \sigma_{u0}\lambda_0} \quad (10)$$

while the counterfactual outcome for non-participants had they participated is:

$$\mathbf{E(Y_{1i}|C_i = 0) = X_{0i}\beta_1 + \sigma_{u1}\lambda_0} \quad (11)$$

where $\lambda_1 = \varphi(Z\alpha)/\Phi(Z\alpha)$ and $\lambda_0 = -\varphi(Z\alpha)/[1 - \Phi(Z\alpha)]$ are the inverse Mills ratios computed from the selection equation, and φ and Φ are the density and cumulative distribution functions of the standard normal distribution.

The Average Treatment Effect on the Treated (ATT), representing the estimated treatment effect of CFA participation among participating households, is calculated as:

$$\mathbf{ATT = E(Y_{1i}|C_i = 1) - E(Y_{0i}|C_i = 1)} \quad (12)$$

The Average Treatment Effect on the Untreated (ATU), representing the expected gain for non-participants if they joined CFAs, is calculated as:

$$\mathbf{ATU = E(Y_{1i}|C_i = 0) - E(Y_{0i}|C_i = 0)} \quad (13)$$

2.3.5 Measurement of livelihood diversification

To examine whether CFA participation contributes to broader livelihood transformation, income diversification was measured using the Simpson Diversification Index (SID), commonly applied in livelihood studies because it captures both the number and distribution of income sources. Income diversification and the rural non-farm economy have been widely studied (Bezu & Barrett, 2012; Reardon, 1997).

The index is specified as:

$$\boldsymbol{SID_i = 1 - \sum_{j=1}^{J} P_{ij}^2} \quad (14)$$

where:

$$\mathbf{P_{ij}} = \frac{\boldsymbol{Income_{ij}}}{\boldsymbol{Total\ Household\ Income_i}} \quad (15)$$

(P_{ij}) represents the share of total household income obtained from livelihood activity (j). The index ranges between 0 and 1, where values closer to 1 indicate greater income diversification. This empirical approach allows the study to determine whether CFA participation simply increases access to forest resources or contributes to broader livelihood transformation through diversified and resilient income pathways.

3 Results

3.1 Household characteristics and livelihood differences by CFA membership status

Table 1 presents the differences in socio-economic characteristics, access to institutions and livelihood outcomes between CFA member and non-member households. Demographic characteristics of CFA and non-CFA households were more or less similar. About 79% of CFA households and 77% of non-CFA households were headed by a male. Average household size was around four members for both CFA and non-CFA households. The household heads had about 9 years of formal education and the average age was between 44 and 46 years.

Forest governance access and engagement was more differentiated by institutional access. CFA households had higher access to extension and advisory information services (91%) than non-CFA households (79%). CFA members were also more likely than non-members to have access to support activities for forest governance (19% compared with 14%). CFA members were slightly more involved in PELIS activities and were more involved in specialized forest user groups such as grazing associations.

Livelihood outcomes showed mixed patterns. CFA members reported slightly higher forest-resource income (KES 21,747) compared with non-members (KES 21,006), whereas total household income was very similar between the two groups (approximately KES 14,100).

Table 1: Socio-economic characteristics, institutional access, and livelihood outcomes by CFA membership status

Variable	Non-CFA members (n=1,474) Mean (SD)	CFA members (n=430) Mean (SD)	Mean difference
Household socio-demographic characteristics			
Male household head (1=yes)	0.769 (0.422)	0.791 (0.407)	−0.022
Household size (number)	4.274 (2.019)	4.284 (2.180)	−0.010
Education of household head (years)	8.901 (3.872)	8.805 (3.448)	0.096
Age of household head (years)	44.333 (12.424)	45.947 (10.450)	−1.613
Forest governance and institutional engagement			
PELIS plots cultivated (number)	1.285 (0.572)	1.358 (0.642)	−0.073
Forest governance support received (1=yes)	0.140 (0.347)	0.192 (0.395)	−0.052
Extension/advisory information access (1=yes)	0.791 (0.407)	0.907 (0.291)	−0.116
Forest grazing group membership (1=yes)	0.005 (0.069)	0.021 (0.143)	−0.016
Forest enterprise/formal contract (1=yes)	0.005 (0.073)	0.009 (0.096)	−0.004
Livelihood diversification and resource access			
Forest-resource extraction participation (1=yes)	0.538 (0.499)	0.507 (0.501)	0.031
Off-farm employment (1=yes)	0.106 (0.308)	0.112 (0.315)	−0.006
Distance to nearest tarmac road (km)	8.499 (4.543)	7.440 (4.694)	1.060
Credit need/access (1=yes)	0.353 (0.478)	0.467 (0.500)	−0.114
Livelihood outcomes			
Total household income (KES)	14,141.78 (2,192.33)	14,085.86 (2,324.22)	55.92
Forest-resource income (KES)	21,005.94 (20,624.90)	21,746.75 (18,803.80)	−740.81

Notes: Values represent sample means with standard deviations reported in parentheses.
Sample size n = 1,904 (1,474 non-CFA members and 430 CFA members).
Income values are reported in Kenyan Shillings (KES).

3.2 Endogenous switching regression estimates of CFA participation and household income outcomes

Table 2 reports the endogenous switching regression (ESR) estimates for the determinants of CFA participation and associated household income outcomes. In the CFA membership equation, education of the household head had a negative and statistically significant coefficient, while age of the household head had a positive and significant effect. Participation in PELIS was associated with a significantly higher likelihood of CFA membership. Distance to the nearest tarmacked road entered with a negative and significant coefficient, and membership in forest grazing groups and access to credit were both positively and significantly associated with CFA participation.

In the income equations, PELIS participation had a positive and significant effect on household income among CFA members, while its effect among non-CFA households was smaller and not statistically significant. Participation in forest grazing management was positively associated with household income in both CFA and non-CFA regimes.

The diagnostic tests for the ESR showed that the estimated correlation parameters between selection and outcome equations were not statistically significant and the likelihood-ratio test did not reject independence between equations ($\chi^2(2) = 0.05$; $p = 0.9766$).

Table 2: Endogenous switching regression estimates of CFA participation and household income.

Variable	Non-CFA members (Regime 0) Coef. (SE)	CFA members (Regime 1) Coef. (SE)	CFA membership equation Coef. (SE)
Household characteristics			
Male household head	−15.79 (152.87)	−96.02 (285.15)	0.051 (0.084)
Household size	27.10 (32.21)	41.55 (52.84)	0.003 (0.017)
Education of household head (years)	−22.20 (18.34)	−56.79 (37.96)	−0.018* (0.009)
Age of household head (years)	−0.68 (5.98)	3.96 (13.03)	0.006** (0.003)
Number of PELIS plots cultivated	38.72 (137.44)	351.03* (227.01)	0.151** (0.060)
Livelihood characteristics			
Off-farm employment	−101.58 (217.45)	−142.23 (371.36)	0.100 (0.114)
Distance to nearest tarmac road (km)	1.45 (20.69)	−59.90 (42.50)	−0.035*** (0.008)
Forest grazing group membership	1586.95* (1118.05)	1339.98* (1289.65)	1.053*** (0.379)
Formal contract participation	−1003.36 (945.45)	300.68 (1370.20)	−0.461 (0.468)
Credit access/need	61.53 (155.50)	192.76 (289.58)	0.186*** (0.072)
Instrument			
Conservation training received			0.144 (0.094)
Constant	14166.88*** (491.04)	13854.64 *** (1988.17)	−0.913*** (0.222)
Sigma0	2175.99		
Sigma1		2252.13	
Rho0	−0.082		
Rho1		0.111	
LR test independence	$\chi^2(2)=0.05$; p=0.9766		

Notes: Standard errors are presented in parentheses below estimated coefficients. The model was estimated using Full Information Maximum Likelihood (FIML). Regime 0 represents non-CFA members; Regime 1 represents CFA members. Conservation training received serves as the exclusion restriction instrument. LR test refers to the Likelihood Ratio test of independent equations ($\chi^2(2) = 0.05$) ; p = 0.9766). Significance levels: *p < 0.10, **p < 0.05 ,***p < 0.01.

3.3 Effect of CFA membership on forest-resource income

Table 3 presents the endogenous switching regression estimates for forest-resource income under CFA participation and non-participation. Among non-CFA households (Regime 0), none of the explanatory variables had a statistically significant effect on forest-resource income. In contrast, several variables were significant for CFA households (Regime 1). Male-headed households had significantly lower forest-resource income than female-headed households ($p < 0.05$).

Additionally, education of the household head was positively associated with forest-resource income ($p < 0.10$), as was the number of PELIS plots cultivated ($p < 0.10$). Participation in forest grazing management also had a positive and statistically significant effect on forest-resource income among CFA members ($p < 0.10$). Other livelihood and institutional variables, including off-farm employment, distance to the nearest tarmac road, formal contract participation and credit access, were not statistically significant in either regime.

Table 3: Endogenous switching regression estimates of CFA participation and forest-resource income.

Variable	Non-CFA members (Regime 0)	CFA members (Regime 1)	CFA membership selection equation
	Coef. (SE)	Coef. (SE)	Coef. (SE)
Household characteristics			
Male household head (1=yes)	291.83 (1520.01)	−6236.53** (2713.95)	−0.014 (0.063)
Household size	96.80 (314.57)	176.15 (509.80)	−0.004 (0.013)
Education of household head (years)	52.53 (170.26)	510.01* (329.95)	−0.003 (0.007)
Age of household head (years)	−17.88 (53.39)	−176.96 (109.03)	0.001 (0.002)
Number of PELIS plots cultivated	14.79 (1131.11)	1764.84* (1753.93)	0.004 (0.047)
Livelihood and institutional factors			
Off-farm employment	35.37 (2109.03)	−418.32 (3506.61)	−0.016 (0.092)
Distance to nearest tarmac road (km)	65.29 (143.01)	211.97 (250.24)	0.0003 (0.007)
Forest grazing management	1051.76 (7839.81)	10115.00*(8947.04)	0.460 (0.326)
Formal contract participation	3062.51 (8586.96)	4344.39 (12806.80)	−0.281 (0.357)
Credit access/need	−562.90 (1312.76)	−3637.51 (2251.50)	0.021 (0.055)
Instrument			
Conservation training received	—	—	0.011 (0.029)
Constant	10133.03**(4014.96)	49070.58*** (7433.14)	−0.345** (0.169)

Notes: Standard errors are presented in parentheses below estimated coefficients. The model was estimated using Full Information Maximum Likelihood (FIML). Regime 0 represents non-CFA members; Regime 1 represents CFA members. Conservation training received serves as the exclusion restriction instrument. Significance levels:*p < 0.10, **p < 0.05 ,***p < 0.01.

3.4 Impact of CFA membership on household livelihood outcomes

The Average Treatment Effects on the Treated (ATT) estimated with endogenous switching regression model to assess the livelihood impacts of membership in a Community Forest Association (CFA) are reported in Table 4.The ATT estimates compare the income outcomes of CFA members with counterfactual predictions of what would have happened to those same households if they had not participated in CFA structures.

The results indicate that participation in CFA is related to higher income on both measures. CFA members reported a household income of KES 35,507 compared to an estimated counterfactual income of KES 29,041 in the absence of participation. This corresponds to an estimated difference of KES 6,465 per household, equivalent to 22.3% of the counterfactual income. Similarly, CFA membership is associated with higher income derived from forest resources. CFA households generated an average forest-resource income of KES 21,049 compared with an estimated counterfactual income of KES 19,585. The estimated difference of KES 1,464 is equivalent to 7.5% of the counterfactual forest-resource income. However, neither estimate is statistically significant at conventional levels (t = 1.29 and 1.38), so these results are suggestive rather than conclusive.

Table 4: Estimated treatment effects of CFA membership on household and forest-resource income -ATT

Outcome variable	Observed outcome for CFA members	Counterfactual outcome (if CFA members had not participated)	ATT	t-value	Change (%)
Household income (KES)	35,507	29,041	6,466	1.29	22.3
Forest-resource income (KES)	21,049	19,585	1,464	1.38	7.5

Notes: ATT represents the Average Treatment Effect on the Treated. Counterfactual values represent predicted outcomes for participating CFA members had they not participated. All income values are expressed in Kenyan Shillings (KES). Percentage change represents the difference between the observed and counterfactual outcomes relative to the counterfactual outcome. t-values are reported; neither ATT estimate is statistically significant at the 10% level.

4 Discussion

This study examined whether participation in Community Forest Associations (CFAs) affects household welfare and forest-resource income, and through which institutional pathways these effects occur. Overall, descriptive and ESR results indicate that CFA membership is driven mainly by institutional and access factors and is associated with higher household and forest incomes, but interpretation requires caution given identification diagnostics.

4.1 Participation, institutional access and household heterogeneity

CFA and non-CFA households were similar on basic demographics but differed markedly in institutional integration: CFA members had greater access to extension, forest-governance support, PELIS participation and grazing-group membership. This pattern aligns with common-pool resource theory emphasizing experience, trust and social capital in collective action and with empirical findings that institutional embedding rather than simple household traits often determines participation in community forestry (Agrawal & Chhatre, 2006; Persha et al., 2011). The negative association between education and CFA membership is consistent with evidence that higher human capital expands non-farm opportunities and reduces dependence on environmental income (Angelsen et al., 2014; Babigumira et al., 2014). The positive association between household head's age and membership may be due to life-cycle effects on household labor and land use (Perz, 2001). The negative effect of distance to tarmac roads further points out the importance of physical accessibility and transaction costs in determining institutional engagement. This finding is in line with the rural livelihood literature that shows that access to infrastructure affects participation in institutions and determines access to economic opportunities (Barrett et al., 2001; Haggblade et al., 2010).

4.2 Livelihood impacts and diversification

ATT estimates show positive associations between CFA membership and total household income (≈22.3%) and forest-resource income (≈7.5%). The larger proportional gain in total

income than in forest income is consistent with CFA benefits that extend beyond direct extraction, in line with the sustainable livelihoods literature that emphasizes diversification as a pathway to welfare gains (Barrett et al. 2001; Ellis 2000). This remains speculative, however, because neither estimate is statistically significant and diversification outcomes were not examined directly. The ESR income equations show that participation in PELIS and regulated grazing are positively related to household income under the CFA regime, suggesting that CFAs can be platforms through which conservation incentives can be linked to productive opportunities (Persha et al. 2011; Sunderlin et al. 2005). Switching-regression analyzes analogous to these have also recorded positive welfare gains for participating smallholders in the setting of agricultural cooperative membership (Abdulai and Huffman 2014).

4.3 Forest-resource income, human capital and gender

Regime-specific estimates show that education, number of PELIS plots, and grazing-group participation are positively associated with forest-resource income among CFA members but not among non-members. This indicates that CFAs and linked programs create structured pathways through which human capital and collective arrangements are converted into forest earnings (Agrawal and Chhatre 2006). The negative association of male-headed households with forest income in the CFA regime highlights the gendered differentiation of beneficiaries from forest activities. This is in line with studies that show women's central role in the collection of non-timber forest products and gendered access to benefits (Coleman and Mwangi 2013; Sunderland et al. 2014). Intra-household bargaining power and control of resources may also influence these patterns.

4.4 Identification, diagnostics and limitations

The ESR diagnostics report non-significant selection outcome correlations and a likelihood-ratio test that fails to reject independence ($\chi^2(2)=0.05$; $p=0.9766$), and the exclusion instrument (conservation training) is not strongly significant in the selection equation. While

these results reduce evidence of unobserved selection bias, they also limit the model's identifying leverage and imply that findings should be interpreted primarily as conditional associations rather than definitive causal estimates (Lokshin and Sajaia 2004). Future research could use control-function approaches and formal instrument tests to strengthen identification.

5 Conclusion

There has been a growing call for community-based approaches to forest governance as a way to achieve both conservation outcomes and improved rural livelihoods. However, there is lack of empirical evidence that participation in Community Forest Associations (CFAs) leads to tangible livelihood benefits to forest-dependent households. This study contributes to filling this evidence gap by examining the impact of participation in CFA on household income and forest resource income in communities around selected forest ecosystems in Kenya. Using an endogenous switching regression approach, the study accounted for differences between CFA and non-CFA households and estimated the livelihood outcomes associated with participation.

Results indicate that institutional and resource access factors are more important than basic household demographic characteristics in determining CFA participation. Households' participation in PELIS, involvement in forest-resource user groups and access to credit were key factors connecting households to community forest governance structures. This suggests that households engage with CFAs not only for access to forest resources but also as platforms for information exchange, capacity strengthening, and livelihood opportunities.

The results further suggest that CFA participation is associated with higher household welfare. The estimated treatment effects indicate that CFA members had higher household income than their predicted counterfactual outcomes had they not participated, and CFA membership was also associated with higher forest-resource income, although the magnitude of this effect was

smaller than the overall household income effect. Neither estimate is statistically significant at conventional levels, and the diagnostic tests do not detect selection on unobservables, so these results should be read as conditional associations rather than causal effects. They are consistent with the benefits of participatory forest management extending beyond direct extraction of forest products, although diversification outcomes were not examined directly here.

The study highlights that forest governance institutions may generate livelihood benefits when participation is combined with productive resource access and complementary support systems. In particular, PELIS participation and organized forest-user groups were associated with higher income among CFA members. These findings are consistent with the argument that community forestry should move beyond resource access alone toward integrated models that combine conservation objectives with livelihood development.

Thus, from the policy perspective, it is important to strengthen CFAs as livelihood-oriented institutions for enhancing the effectiveness of participatory forest management. First, investments should focus on enhancing conservation training, governance capacity, financial literacy and enterprise-development skills among CFA members. These capacity building efforts may improve the capacity of households to utilize forest resources in a sustainable manner. Second, forest-based livelihood programs should emphasize value addition and opportunities for commercialization. Income diversification without jeopardizing conservation objectives can be achieved by promoting the expansion of agroforestry, sustainable non-timber forest products, beekeeping, ecotourism and other nature-based enterprises. Linking CFA members to markets, finance, and technical support will be important for transforming forest participation into sustainable livelihood gains.

Thirdly, there is need to strengthen institutional linkages among the CFAs, Kenya Forest Service, extension providers, financial institutions and private sector actors. Improved coordination can enhance access to advisory services, market information, and investment opportunities needed for sustainable forest-based enterprises.

In general, the study suggests that CFAs could be platforms for livelihoods as well as their conservation mandate. But for their greatest impact, there is a need to shift from participation-based approaches toward models that build household capabilities, strengthen collective action and create sustainable economic opportunities in forest-adjacent communities.

Statements and Declarations

Funding

This work was supported by the African Development Bank under the Green Zones Development Support Project Phase II (GZDSP II).

Competing Interests

The authors have no competing interests to declare that are relevant to the content of this article.

Ethics Approval

Ethical clearance was obtained from the National Commission for Science, Technology and Innovation (NACOSTI), Kenya (Approval Protocol No. NACOSTI/P/23/24331).

Consent to Participate

Written informed consent was obtained from each individual participant included in the study. Participation was voluntary. Participants were informed about the aim of the study and their right to withdraw at any time without any negative consequence. The survey team was trained on research ethics, informed consent process, survey protocol and confidentiality. All data were anonymized prior to analysis to protect participant privacy.

Availability of Data and Material

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Authors' Contributions

Castro N. Gichuki: Conceptualization, methodology, formal analysis, funding acquisition, writing original draft, writing review and editing. Charles K. Wambu: Conceptualization, investigation, data curation, supervision, project administration, writing review and editing. Both authors read and approved the final manuscript.

References

Abdulai A, Huffman W (2014) The adoption and impact of soil and water conservation technology: an endogenous switching regression application. Land Econ 90(1):26–43. https://doi.org/10.3368/le.90.1.26

Agrawal A, Chhatre A (2006) Explaining success on the commons: community forest governance in the Indian Himalaya. World Dev 34(1):149–166. https://doi.org/10.1016/j.worlddev.2005.07.013

Agrawal A, Gibson CC (1999) Enchantment and disenchantment: the role of community in natural resource conservation. World Dev 27(4):629–649. https://doi.org/10.1016/S0305-750X(98)00161-2

Angelsen A, Wunder S (2003) Exploring the forest–poverty link: key concepts, issues and research implications. CIFOR Occasional Paper No. 40. Center for International Forestry Research, Bogor

Angelsen A, Jagger P, Babigumira R, Belcher B, Hogarth NJ, 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

Babigumira R, Angelsen A, Buis M, Bauch S, Sunderland T, Wunder S (2014) Forest clearing in rural livelihoods: household-level global-comparative evidence. World Dev 64:S67–S79. https://doi.org/10.1016/j.worlddev.2014.03.002

Barrett CB, Reardon T, Webb P (2001) Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. Food Policy 26(4):315–331. https://doi.org/10.1016/S0306-9192(01)00014-8

Bebbington A (1999) Capitals and capabilities: a framework for analyzing peasant viability, rural livelihoods and poverty. World Dev 27(12):2021–2044. https://doi.org/10.1016/S0305-750X(99)00104-7

Bezu S, Barrett C (2012) Employment dynamics in the rural nonfarm sector in Ethiopia: do the poor have time on their side? J Dev Stud 48(9):1223–1240. https://doi.org/10.1080/00220388.2012.671474

Carter MR, Barrett CB (2013) The economics of poverty traps and persistent poverty: an asset-based approach. In: Chuhan-Pole P, Angwafo M (eds) Yes Africa can: success stories from a dynamic continent. World Bank, Washington, DC, pp 12–33

Chidumayo EN, Gumbo DJ (eds) (2010) The dry forests and woodlands of Africa: managing for products and services. Earthscan, London

Chirenje LI, Giliba RA, Musamba EB (2013) Local communities' participation in decision-making processes through planning and budgeting in African countries. Chin J Popul Resour Environ 11(1):10–16. https://doi.org/10.1080/10042857.2013.777198

Coleman EA, Mwangi E (2013) Women's participation in forest management: a cross-country analysis. Glob Environ Change 23(1):193–205. https://doi.org/10.1016/j.gloenvcha.2012.10.005

Ellis F (2000) Rural livelihoods and diversity in developing countries. Oxford University Press, Oxford

FAO (2020) The state of the world's forests 2020: forests, biodiversity and people. Food and Agriculture Organization of the United Nations, Rome. https://doi.org/10.4060/ca8642en

Githiomi JK, Oduor N (2012) Strategies for sustainable wood fuel production in Kenya. Int J Appl Sci Technol 2(10):23–28

Haggblade S, Hazell P, Reardon T (2010) The rural non-farm economy: prospects for growth and poverty reduction. World Dev 38(10):1429–1441. https://doi.org/10.1016/j.worlddev.2009.06.008

Heckman JJ (1979) Sample selection bias as a specification error. Econometrica 47(1):153–161. https://doi.org/10.2307/1912352

Kenya Forest Service (2021) National forest resource assessment report 2021. Kenya Forest Service, Nairobi

Koech C, Ongugo P, Mbuvi M, Maua J (2009) Community Forest Associations in Kenya: challenges and opportunities. KEFRI Research Report. Kenya Forestry Research Institute, Muguga

Lokshin M, Sajaia Z (2004) Maximum likelihood estimation of endogenous switching regression models. Stata J 4(3):282–289. https://doi.org/10.1177/1536867X0400400306

Mogoi J, Obonyo E, Ongugo P, Oeba V, Mwangi E (2012) Communities, property rights and forest decentralisation in Kenya: early lessons from participatory forestry management. Conserv Soc 10(2):182–194. https://doi.org/10.4103/0972-4923.97488

Mutune JM, Lund JF (2016) Unpacking the impacts of 'participatory' forestry policies: evidence from Kenya. For Policy Econ 69:45–52. https://doi.org/10.1016/j.forpol.2016.04.004

Nath TK, Inoue M (2010) Impacts of participatory forestry on livelihoods of ethnic people: experience from Bangladesh. Soc Nat Resour 23(11):1093–1107. https://doi.org/10.1080/08941920903422894

Persha L, Agrawal A, Chhatre A (2011) Social and ecological synergy: local rulemaking, forest livelihoods, and biodiversity conservation. Science 331(6024):1606–1608. https://doi.org/10.1126/science.1199343

Perz SG (2001) Household demographic factors as life cycle determinants of land use in the Amazon. Popul Res Policy Rev 20(3):159–186. https://doi.org/10.1023/A:1010697906950

Reardon T (1997) Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. World Dev 25(5):735–747. https://doi.org/10.1016/S0305-750X(96)00137-4

Shackleton CM, Shackleton SE, Cousins B (2001) The role of land-based strategies in rural livelihoods: the contribution of arable production, animal husbandry and natural resource harvesting in communal areas in South Africa. Dev South Afr 18(5):581–604. https://doi.org/10.1080/03768350120097441

Sunderland T, Achdiawan R, Angelsen A, Babigumira R, Ickowitz A, Paumgarten F, Reyes-García V, Shively G (2014) Challenging perceptions about men, women, and forest product use: a global comparative study. World Dev 64:S56–S66. https://doi.org/10.1016/j.worlddev.2014.03.003

Sunderlin WD, Angelsen A, Belcher B, Burgers P, Nasi R, Santoso L, Wunder S (2005) Livelihoods, forests, and conservation in developing countries: an overview. World Dev 33(9):1383–1402. https://doi.org/10.1016/j.worlddev.2004.10.004

Wunder S, Angelsen A, Belcher B (2014) Forests, livelihoods, and conservation: broadening the empirical base. World Dev 64:S1–S11. https://doi.org/10.1016/j.worlddev.2014.03.0071.