

Forest Income and Income Inequality: A Gini Coefficient and Lorenz Curve Analysis of Non-Timber Forest Produce Income Across Forest Circles of Chhattisgarh, India

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Abstract

Non-timber forest produce (NTFP) constitutes a critical supplementary livelihood source for forest-fringe and tribal households in central India, yet its distributive consequences for household income inequality remain insufficiently quantified at the sub-state level.

Objective: This study examines whether NTFP income exerts an equalizing or disequalizing influence on the distribution of household income among NTFP-dependent households in Chhattisgarh.

Methods: A multi-stage random sample of 315 households was drawn from three forest circles Raipur, Kanker and Surguja. Gini coefficients were estimated from exact household-level income data using the trapezoidal approximation to the Lorenz curve, computed separately for total household income with and without NTFP income for the pooled sample from each forest circle. corresponding Lorenz curves were constructed and compared against the line of perfect equality.

Results: The overall Gini coefficient declined from 0.4163 (without NTFP income) to 0.3816 (with NTFP income), a reduction of 8.35 per cent, confirming the equalizing role of NTFP income in the aggregate sample. At the forest-circle level, the equalizing effect ranged from a marginal 3.29 per cent reduction in Raipur to substantial reductions of 11.12 per cent in Kanker and 12.19 per cent in Surguja, reflecting circle-specific differences in the socio-economic profile of collectors and the degree of NTFP trade commercialization.

Policy implications: NTFP income functions as a progressive, redistributive component of rural household livelihoods in Chhattisgarh; strengthening NTFP collection, processing, and marketing infrastructure including Minimum Support Price (MSP) mechanisms is likely to generate both income level and distributive benefits with the magnitude contingent on local forest-circle context.

1. Introduction

Non-timber forest products (NTFPs) fruits, flowers, seeds, leaves, resins, and other resources harvested from forests without felling timber are an important source of subsistence and monetary revenue for forest-dependent people worldwide. Comparative evidence shows that forest and natural-resource income accounts for a substantial share of total household income in rural areas, typically between one-fifth and more than one quarter of household earnings (Cavendish, 2000, Vedeld et al., 2007, Angelsen et al., 2014). Environmental resources have been found to contribute roughly 35 per cent of total household income in rural Zimbabwe, rising to about 40 per cent for the poorest households (Cavendish, 2000). Such income also functions as a safety net during seasonal shortfalls and shocks. a synthesis of South African evidence across fourteen villages found that core products wild spinaches, fuelwood, edible fruits, and wooden utensils were used by 85 per cent or more of households, with annual direct-use values ranging from under ₹1,000 to more than ₹12,000 per household in South African rand terms (Shackleton & Shackleton, 2004). A meta-analysis of fifty-one case studies across seventeen countries placed average forest environmental income at roughly 22 per cent of total household income (Vedeld et al., 2007), while a study of about eight thousand households across twenty-four developing countries estimated total

environmental income at close to 28 per cent of which forest environmental income alone accounted for about 22 per cent. the majority originating from natural forests (Angelsen et al., 2014). This evidence rests on a broadening empirical base linking forests, livelihoods and conservation (Wunder et al., 2014).

The distributional dimension of NTFP income a concept refined over two decades (Sjaastad et al., 2005) has received comparatively less, though growing, attention at the global level. Cross-country evidence suggests that environmental income is relatively pro-poor. poorer households tend to derive a larger share of their income from the environment and its inclusion has been found to reduce measured rural poverty and within-site inequality (Angelsen et al., 2014, Babulo et al., 2008). Household-level evidence from 360 collector households across twelve villages in Tigray, northern Ethiopia, similarly shows poorer households depending proportionally more on forest income than better-off ones (Babulo et al., 2008). In absolute terms, wealthier households often capture larger gains (Cavendish, 2000) and a global assessment of sixty-one commercial NTFP cases spanning Africa, Asia, and Latin America concluded that while trade benefits livelihoods it may widen inequality between households (Belcher et al., 2005). The equalizing effect is therefore not guaranteed and depends on the specific produce, market structure and cost environment, as the experience of natural-product trade in semi-arid settings also illustrates (Shackleton et al., 2008). Studies across diverse forest ecosystems have further quantified this distributional role using formal inequality measures. In northern Benin, West Africa NTFPs contributed 39 per cent of total household income among 230 households and represented the second most important livelihood source after crop production. inclusion of NTFP income reduced the Gini coefficient from 0.61 to 0.23 (Heubach et al., 2011). In south-eastern Burkina Faso, NTFPs accounted for 45 per cent of total household income and served as an important buffer against income fluctuations, with their inclusion reducing the Gini coefficient from 0.62 to 0.21 among the largest equalizing effects documented in the literature (Leßmeister et al., 2018). Around the West Usambara Mountain forests of Tanzania, NTFPs contributed a comparatively modest 6 per cent of total household income among 159 households yet their inclusion still reduced the Gini coefficient from 0.37 to 0.35 (Luswaga & Nuppenau, 2022). In Xishuangbanna, south-west China excluding NTFP income increased the Gini coefficient from 0.393 to 0.414, with households possessing better market access and greater labour availability participating more actively in NTFP trade (Fu et al., 2009). Collectively, these studies document NTFP income shares ranging from roughly 6 to over 53 per cent of total household income across diverse forest ecosystems, and consistently find that the inclusion of forest income reduces measured inequality evidence that NTFPs function not merely as a supplementary income source but as a livelihood asset supporting poverty reduction, income diversification, and economic resilience.

In India, NTFPs administratively termed Minor Forest Produce (MFP) underpin the economy of a very large number of forest-dwelling households with an estimated one hundred million people deriving livelihood directly from their collection and trade. the annual value of MFP transactions is placed at around ₹20,000 crore and tribal households typically draw 20–40 per cent of their yearly income from MFP collection and sale (Ministry of Tribal Affairs, 2020). The reliance is widespread at the household level. in the dry deciduous forests of Orissa and Jharkhand, about 95 and 62 per cent of surveyed households. respectively, earned cash income from NTFP sales with the contribution varying systematically by season,

ecological setting, income level and caste (Mahapatra et al., 2005). The resource base itself is valuable the net present value of NTFP revenues from these forests has been estimated at roughly US\$1,016 per hectare, so that per-hectare returns from NTFPs in dry deciduous forests can rival or exceed those from alternative land uses (Mahapatra et al., 2005; Mahapatra & Tewari, 2005). The distributional pattern within India mirrors the global evidence. in the Kashmir Himalayas, NTFPs constituted the single largest source of household income, contributing on average ₹35,817.91 annually and accounting for 53.33 per cent of total household income exceeding earnings from agricultural crops, livestock, wage labour and dairy combined while substantially reducing income inequality among forest-dependent households (Peerzada et al., 2022). Yet primary collectors across the country typically remain at the lower end of the value chain owing to information asymmetry, weak bargaining power and inadequate primary-processing infrastructure (Ministry of Tribal Affairs, 2020; Sagar, 2025). To strengthen these livelihoods the Government of India operates the Minimum Support Price (MSP) scheme for MFP, in operation since 2011 and now covering a substantially expanded list of items and the Van Dhan Vikas Yojana launched in 2018 which establishes community-owned Van Dhan Kendras for procurement and value addition (Ministry of Tribal Affairs, 2020; Sagar, 2025).

Chhattisgarh is among the most forested states in the country, ranking third nationally in forest-cover area at roughly 55,800 km² close to 41 per cent of the state's geographical area (Forest Survey of India, 2024) and a substantial proportion of its population belongs to Scheduled Tribe communities, who number about 7.8 million and constitute close to 31 per cent of the state's population of 25.5 million (Census of India, 2011). Economically important produce such as tendu (*Diospyros melanoxylon*), mahua (*Madhuca indica*), sal seed (*Shorea robusta*), harra (*Terminalia chebula*) and chironji (*Buchanania lanzan*) provides seasonal liquidity and food security to collector households. While the aggregate contribution of NTFPs to tribal incomes in the state is well documented far less is known about how those incomes are distributed among collectors. If costs fall proportionally harder on small collectors net returns may be more concentrated than gross returns and interventions targeting the cost structure could have an equalizing effect a question that has not previously been examined for this region.

The present study addresses this gap for 315 NTFP collector households across the Raipur, Kanker and Surguja Forest Circles of Chhattisgarh. The specific objective is to quantify and compare inequality in household income with and without NTFP income at the state level and by forest circle using the Lorenz curve (Lorenz, 1905) and the Gini coefficient (Gini, 1912).

Contribution to the literature: This study provides the first household-level Gini and Lorenz curve analysis of NTFP income inequality disaggregated by forest circle in Chhattisgarh, linking observed circle-level heterogeneity in the equalizing effect to differences in market commercialization and thereby offering a direct, sub-state evidence base for the design of circle-differentiated MSP and NTFP marketing policy in central India.

2. Materials and methods

2.1 Study area and sampling

The study was conducted in Chhattisgarh, a forest-rich state of central India with extensive tribal and forest-fringe settlement. A multi-stage random sampling design was used to select 315 NTFP-dependent households from three forest circles representing distinct agro-ecological and administrative zones of the state: Raipur (n = 105), Kanker (n = 90), and Surguja (n = 120). These circles were purposively selected to capture variation in forest type, market accessibility, and the institutional density of NTFP collection and marketing infrastructure, including primary collection centres operated under the state MSP scheme for Minor Forest Produce.

2.2 Data collection and income aggregation

Primary data were collected through a structured household interview schedule administered to the head, or a knowledgeable adult member of each sample household. For every household income was recorded under four heads for the reference agricultural year. agricultural income, livestock income, non-farm income (including wage labour and salaried employment), and NTFP income (net of collection and primary-processing costs). Two household income aggregates were then constructed. Household Income Without NTFP defined as the sum of agricultural, livestock and non-farm income and Household Income With NTFP defined as Household Income, agricultural, livestock and non-farm income plus NTFP income. Constructing these two aggregates from the same household-level data allows the marginal distributive contribution of NTFP income to be isolated while holding all other income sources constant.

2.3 Gini coefficient estimation

The Gini coefficient was estimated using the trapezoidal approximation to the Lorenz curve (Gini, 1912, Lorenz, 1905), applied to households ranked in ascending order of income:

$$G = 1 - \sum_{i=1}^n (X_i - X_{i-1})(Y_i + Y_{i-1}) \quad (1)$$

where

X_i is the cumulative proportion of households.

Y_i is the cumulative proportion of income at the i -th ranked household with $X_0 = Y_0 = 0$ and $n = 315$.

The coefficient G ranges from 0 (perfect equality) to 1 (perfect inequality). Estimation was performed independently for the Without-NTFP and With-NTFP income series, using exact household-level observations rather than decile or quintile grouped approximations for the pooled sample ($N = 315$) and separately for each forest circle. The Gini coefficient and its companion Lorenz curve were selected over alternative inequality indices (e.g., the Theil or Atkinson index) because they permit direct, easily interpretable graphical comparison of the Without-NTFP and With-NTFP income distributions at both the pooled and forest-circle level and because the trapezoidal method accommodates exact, ungrouped household-level data without requiring an assumed distributional form.

2.4 Lorenz curve construction

For each scenario and level of disaggregation, households were ranked in ascending order of income and cumulative population shares were plotted against cumulative income shares to trace the empirical Lorenz curve. The vertical distance between each Lorenz curve and the diagonal line of perfect equality provides a graphical representation of inequality magnitude that complements the scalar Gini coefficient. curves lying closer to the diagonal indicate more equal distributions, while greater concavity away from the diagonal indicates higher inequality. All statistical computations and visualizations were performed in Python (matplotlib, NumPy) applied to the household-level survey dataset.

2.5 Methodological assumptions and limitations

The analysis assumes that reported household income figures accurately reflect actual receipts net of the stated costs, and that the single reference agricultural year is representative of typical household income patterns. Because NTFP income was recorded net of collection and primary-processing costs while the underlying gross-versus-net cost structure was not separately decomposed by income decile, the analysis identifies the net distributive contribution of NTFP income rather than isolating the equalizing or concentrating role of the cost structure itself; this distinction is addressed further in Section 6 (Limitations).

3. Results

3.1 Descriptive statistics of household income

Table 1

presents descriptive statistics for the four income components and the total household income aggregate across the pooled sample of 315 households.

Income Component	N	Mean (₹)	Median (₹)	S.D. (₹)	Min. (₹)	Max. (₹)	C.V. (%)
Agriculture income	315	90,428.86	75,807.29	82,274.41	8,000.00	611,700.40	90.98
Livestock income	315	49,252.38	0.00	358,751.39	13,000.00	3,688,000.00	728.39
Non-farm income	315	70,541.66	46,970.00	93,450.11	0.00	1,080,000.00	132.48
NTFP income	315	14,593.05	9,586.00	13,792.61	-371.00	78,485.00	94.51
Total household income	315	224,815.95	159,048.90	378,791.73	48,427.11	3,897,435.48	168.49

Mean NTFP income was ₹14,593.05 per household, with a coefficient of variation of 94.51 per cent, indicating substantial heterogeneity in NTFP earnings across households, consistent with differential access to forest resources, collection effort, and species availability. Total household income averaged ₹224,815.95, with livestock income exhibiting the highest relative dispersion (C.V. = 728.39 per cent)

reflecting a small number of households with large livestock holdings that pull the distribution's tail. This heterogeneity in the underlying income components motivates the household-level, rather than aggregate, approach to inequality measurement adopted below.

3.2 Overall income inequality, with and without NTFP income

Table 2
presents the overall Gini coefficient for the pooled sample, with and without the inclusion of NTFP income.

Scenario	Gini Coefficient
Without NTFP income	0.4163
With NTFP income	0.3816
Net change	-0.0348 (- 8.35%)

The overall Gini coefficient declined from 0.4163 (without NTFP income) to 0.3816 (with NTFP income), a reduction of 0.0348 points, or 8.35 per cent. Figure 1 presents the corresponding Lorenz curves.

The Lorenz curve for the With-NTFP scenario lies consistently closer to the line of equality than the Without-NTFP curve across the income distribution, with the gap most pronounced in the lower and middle deciles. This pattern indicates that the equalizing contribution of NTFP income accrues disproportionately to lower- and middle-income households, in line with the pro-poor distributive role documented for NTFP income elsewhere (see Section 4).

3.3 Forest circle-wise income inequality

Raipur recorded the highest baseline inequality among the three circles ($G = 0.4320$ without NTFP) but the smallest equalizing effect of NTFP income ($- 3.29$ per cent), consistent with a more commercialized local NTFP trade that is accessible to comparatively better-off households with transport and storage capacity. Kanker exhibited the highest baseline Gini coefficient of the three circles (0.4663) but the largest equalizing effect ($- 11.12$ per cent), suggesting that NTFP income is of particular importance to Kanker's most income-constrained households. Surguja showed the lowest baseline inequality (0.2731) yet the largest proportionate reduction ($- 12.19$ per cent), implying that even where the underlying income distribution is comparatively equal NTFP income confers an additional, meaningful equalizing effect. Together, these circle-level results indicate that the redistributive function of NTFP income is not uniform across Chhattisgarh but is systematically related to the local degree of NTFP market commercialization a pattern with direct implications for the geographic targeting of NTFP policy (Section 5).

Table 3 disaggregates the Gini coefficient estimates by forest circle.

Table 3
Gini coefficient of household income, with and without NTFP income, by forest circle.

Forest Circle	N	Gini (Without NTFP)	Gini (With NTFP)	Absolute Change	% Change
Overall Chhattisgarh	315	0.4163	0.3816	-0.0348	-8.35
Raipur	105	0.4320	0.4178	-0.0142	-3.29
Kanker	90	0.4663	0.4144	-0.0518	-11.12
Surguja	120	0.2731	0.2399	-0.0333	-12.19

4. Discussion

The consistent decline in the Gini coefficient upon inclusion of NTFP income observed in the pooled sample and independently replicated in all three forest circles provides robust evidence that NTFP-based livelihoods function as a distributionally progressive component of rural household income in Chhattisgarh. This finding is broadly consistent with evidence from Cambodia where forest income was found to be strongly inequality-reducing at the village level (Nhem et al., 2018) and from south-eastern Nigeria where forest income lowered both poverty and inequality among sampled households (Fonta & Ayuk, 2013). It also aligns with the broader literature characterizing NTFP income as a relatively accessible "safety net" resource disproportionately drawn upon by asset and land poor households during periods of agricultural income shortfall (Pattanayak & Sills, 2001, Wunder et al., 2014).

The marked heterogeneity in the magnitude of the equalizing effect across forest circles, however, qualifies any uniform, state-level characterization of NTFP income as equalizing. The comparatively muted effect observed in Raipur mirrors findings from Odisha, India, where deregulation of NTFP marketing channels was associated with a shift toward more commercialized, trader-mediated trade patterns that altered the distribution of benefits among local collectors (Mahapatra & Shackleton, 2011). Greater market integration and infrastructure access in Raipur circle may similarly be enabling relatively better-off households to participate more fully in NTFP collection and sale, thereby diluting the redistributive function that NTFP income performs more strongly in the less commercialized Kanker and Surguja circles. This circle-level heterogeneity is consistent with international evidence that the poverty and inequality-reducing potential of NTFPs is highly contingent on local ecological, market and institutional conditions rather than being a uniform property of forest income as such (Shackleton & Pandey, 2014 Mukul et al., 2016).

5. Policy implications

These findings carry direct implications for forest and tribal livelihood policy in Chhattisgarh and more broadly for MFP-dependent regions of central India. First, because the equalizing effect of NTFP income is strongest where commercialization is least advanced interventions delivered through the Minimum Support Price (MSP) scheme for MFP operationalized in Chhattisgarh through the Chhattisgarh Minor

Forest Produce (Trading and Development) Cooperative Federation (CGMFPFED) and complementary mechanisms such as Van Dhan Vikas Kendras under TRIFED's Van Dhan Vikas Yojana appear well placed to generate not only income gains but also genuine distributive benefits for forest-fringe households. It provided procurement networks are extended to the more remote asset-poor collectors who currently derive the largest equalizing benefit from NTFP income.

Second, the substantially weaker equalizing effect observed in Raipur suggests that policy design should not assume uniform distributive outcomes across forest circles. Circle differentiated interventions for instance prioritizing primary collection centres, price-support coverage and value-addition infrastructure in more commercialized circles such as Raipur may be required to extend the stronger equalizing benefits already observed in Kanker and Surguja to circles where market forces are diluting the redistributive role of NTFP trade.

Third, strengthening NTFP value chains through improved primary processing, storage, and market linkages for produce such as tendu, mahua, sal seed, harra, and chironji is likely to support both income growth and equity objectives simultaneously, reducing the trade-off that policymakers often face between livelihood promotion and distributive equity. Such interventions also contribute to climate-resilient rural livelihood strategies, since NTFP income diversifies forest-fringe households away from sole reliance on rain-fed agriculture, and they are directly relevant to national and international development commitments, including Sustainable Development Goal 1 (No Poverty) and Goal 10 (Reduced Inequalities), by demonstrating a concrete, measurable channel through which forest-based livelihood programmes can advance both poverty reduction and distributive equity in tribal-majority regions.

6. Conclusion

This study estimated household income inequality, with and without NTFP income, among 315 NTFP-dependent households across three forest circles of Chhattisgarh, using Gini coefficients computed from exact household-level data and corresponding Lorenz curves. NTFP income was found to exert a consistent equalizing effect on the distribution of household income, reducing the overall Gini coefficient by 8.35 per cent, with circle-level reductions ranging from 3.29 per cent in Raipur to 12.19 per cent in Surguja. By demonstrating that this redistributive function varies systematically with the local degree of NTFP trade commercialization, the study provides a household-level, forest-circle-disaggregated evidence base that has not previously been available for Chhattisgarh, and identifies commercialization rather than baseline inequality alone as the key contextual factor policymakers should consider when designing MSP and NTFP marketing interventions for tribal and forest-fringe livelihoods in central India.

7. Limitations

This study is subject to several limitations. First, it relies on a single-year, cross-sectional recall of household income, which does not capture inter-annual variability in NTFP availability and prices that may influence year-to-year inequality estimates. Second, self-reported income is potentially subject to recall bias, particularly for irregularly earned non-farm and NTFP income. Third, the sample is geographically

confined to three forest circles and may not fully represent the agro-ecological and institutional diversity of Chhattisgarh's remaining forest circles, or of other MFP-dependent states in central and eastern India. Fourth, NTFP income was aggregated across species without separately quantifying species-specific price and yield variability, which may mask heterogeneity in the equalizing effect attributable to particular produce such as tendu or mahua. Finally, as with any single-region study, the generalizability of the observed magnitudes as opposed to the general direction of the equalizing effect to other states or countries should be treated with appropriate caution.

8. Future research

Future research employing multi-year panel data would allow inter-annual variability in NTFP prices and yields to be incorporated into inequality estimates. Gini decomposition by income source (following, for example, Nhem et al., 2018) and complementary measures such as the Theil index, the Atkinson index, or Shapley-value decomposition would permit more precise quantification of the marginal contribution of NTFP income, and of specific cost components, to overall inequality. Studies that jointly model market integration for instance, distance to primary collection centres or road access alongside household-level inequality would help to test directly the commercialization mechanism proposed here to explain circle-level heterogeneity. Finally, integrating remote sensing and GIS-based forest-resource-access indicators with household survey data, and extending the analytical framework to a longitudinal assessment of climate-resilient livelihood diversification, would strengthen the evidence base linking forest condition, market access, and distributive outcomes for forest-dependent communities.

Declarations

Conflicts of interest/Competing interests

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.

Ethics approval

This study involved a non-invasive, questionnaire-based socio-economic household survey and did not involve any biomedical, clinical, or physically invasive procedures. The research protocol, conducted as part of the corresponding author's doctoral dissertation research, was reviewed and approved by the Institutional Research Committee, Department of Agribusiness and Rural Management, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur. All procedures performed in this study were in accordance with the ethical standards of the institution and with the 1964 Declaration of Helsinki and its later amendments.

Consent to participate

Verbal informed consent was obtained from the head, or a knowledgeable adult member, of each sample household prior to administration of the interview schedule. Respondents were informed of the purpose of

the study, the voluntary nature of their participation, and the confidentiality of the information provided, and were free to withdraw at any stage.

Consent for publication

Not applicable. This manuscript does not contain any individual person's identifiable data, images, or videos.

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Author Contribution

Chandra Kumar: Conceptualization, Methodology, Formal analysis, Data curation, Investigation, Writing original draft, Writing, review & editing, Visualization. Hulas Pathak: Supervision, Methodology, Review & editing. A.K. Gauraha: Supervision, Review & editing Hem Prakash Verma: Investigation, Writing & Editing. Dr. Akash Tiwari: Validation, Resources, Review & Editing. Rahul Kumar Kaushik: Data curation, Validation. All authors reviewed, revised and approved the final manuscript.

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Availability of data and materials

The household survey data underlying this study were collected as part of the corresponding author's doctoral dissertation research at Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur. Data will be made available by the corresponding author upon reasonable request.

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Figures

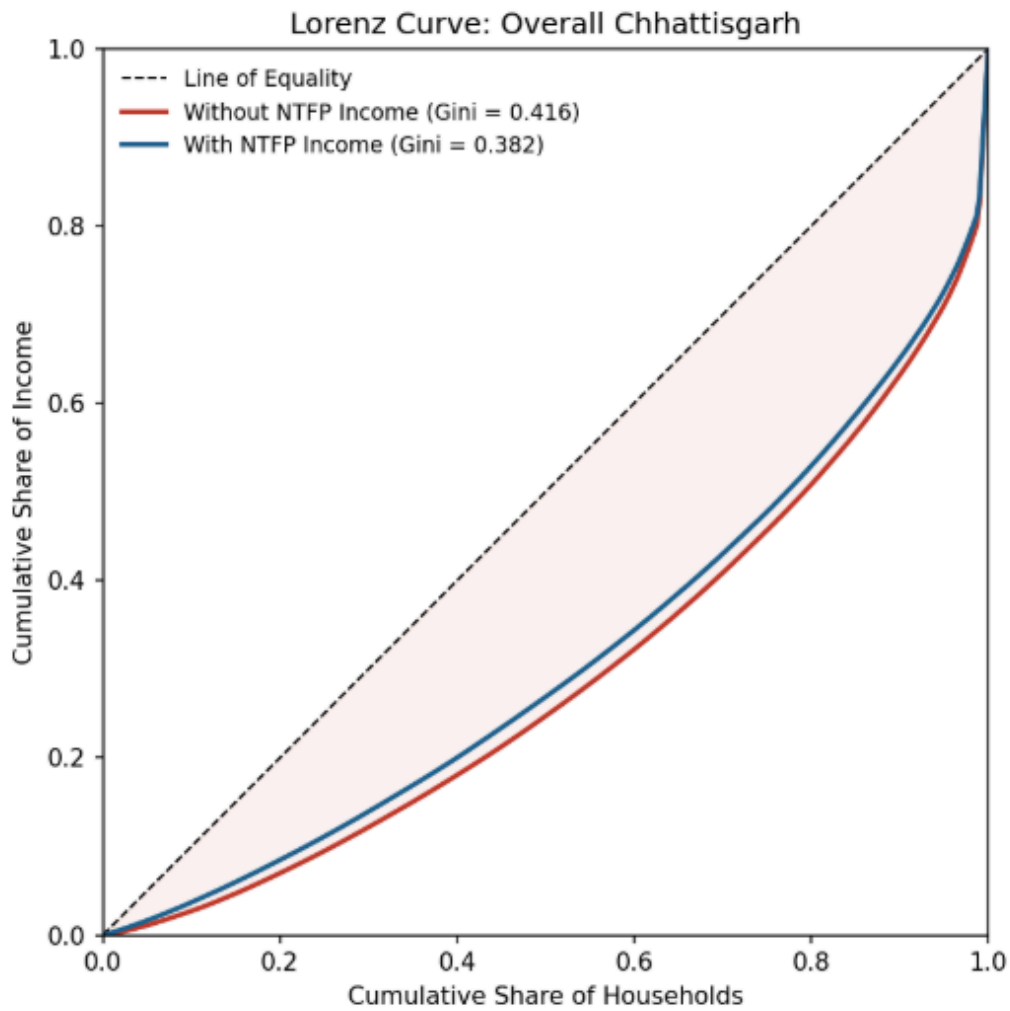


Figure 1

Lorenz curve of household income, overall Chhattisgarh, with and without NTFP income.

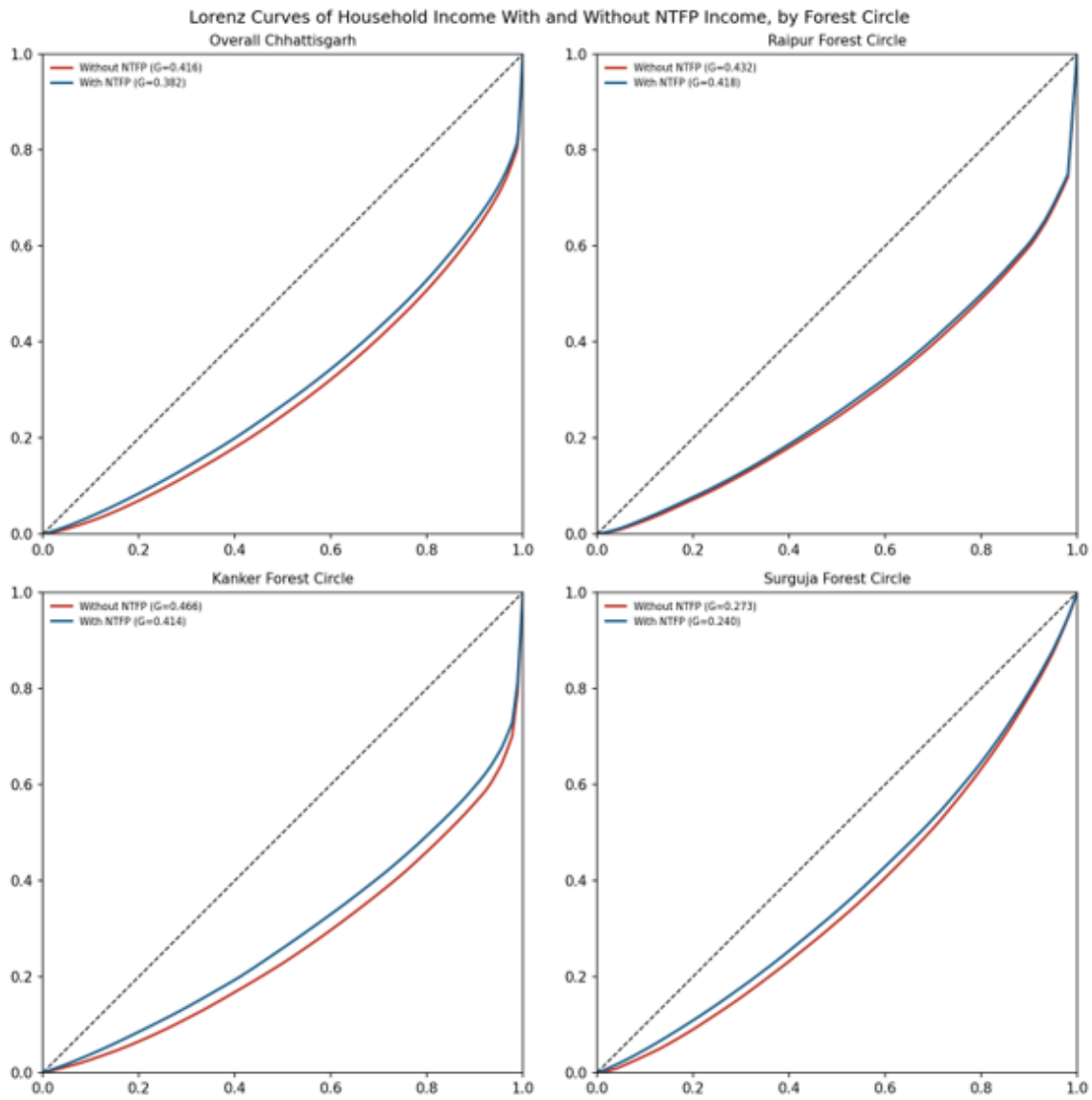


Figure 2

Lorenz curves of household income with and without NTFP income overall and by forest circle.

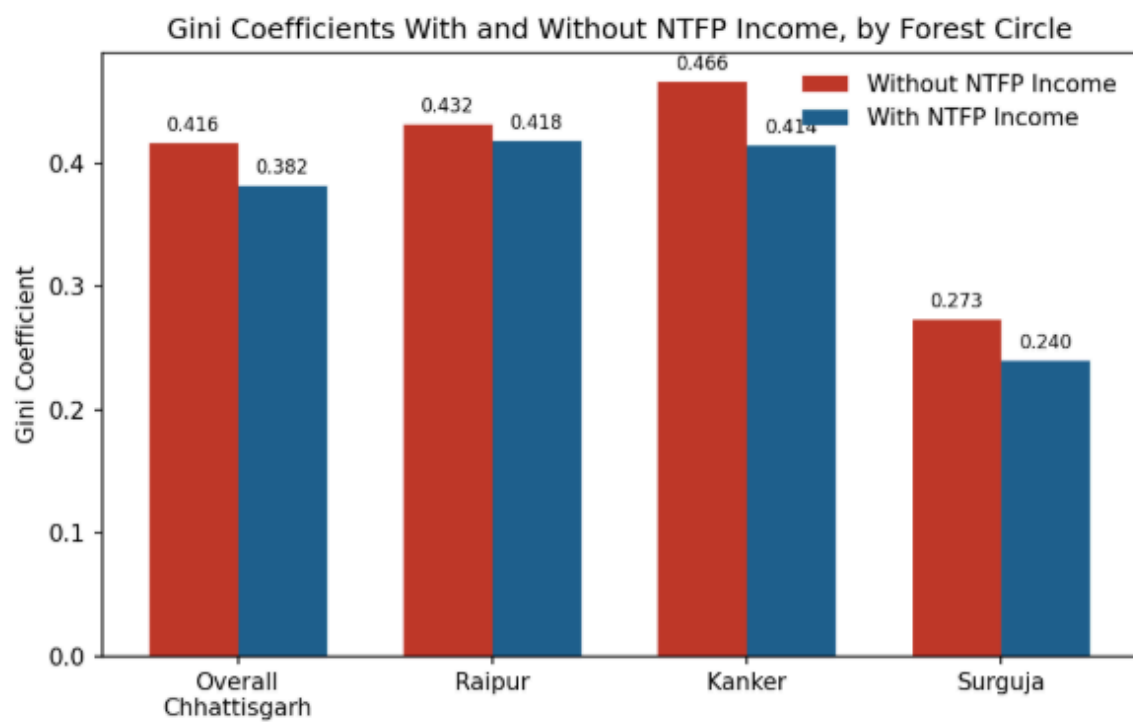


Figure 3

Gini coefficients of household income with and without NTFP income by forest circle.