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Carbon footprints of forest degradation and deforestation by "basic-needs populations": a review

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Abstract

Forest conversion caused by subsistence or "basic needs populations" is difficult to track and measure. As the dynamics of these populations change over time, their carbon footprint impacts on natural resources also change. To reduce their potential negative impacts on forest resources, it is critical to understand what underlying causes influence their livelihoods practices. A systematic review was conducted to search for common basic needs livelihoods that result in forest loss and degradation, and thus in carbon footprint changes. Livelihood activities were grouped into seven themes (animal husbandry, crop production, fishing, illegal practices, non-timber forest products, and wood harvest). Under these themes, a non-comprehensive list of 25 activities was combined with "deforestation" and "forest degradation" as search terms in Scopus and Web of Science™. A two-level snowball sampling procedure was applied to the resulting screened publications. The review produced 2200 outputs, with a final sample of 101 articles and 161 basic needs communities described. The results show that wood harvesting and crop production were the most common livelihood activities engaged in by basic needs populations. Population pressure and alternative income sources were frequently mentioned as underlying causes influencing deforestation and forest degradation and likely affecting carbon footprints through land cover change. Often considered sustainable, livelihood activities by basic needs populations can become unsustainable in response to changes in contextual and socioeconomic factors. These factors are often interrelated, leading to environmental downward spirals, which increase carbon footprints through greater demands for natural resources resulting in deforestation and forest degradation.

Keywords: Livelihoods, poverty, subsistence agriculture, fuelwood, livestock grazing, climate change, forest resources

INTRODUCTION

Some of the world's most vulnerable human populations depend on the resources provided by natural systems, such as tropical forests, for meeting their basic needs. These populations are considered poor as defined by the "basic needs perspective" of the United Nations Development Program (1997)[1]. Such communities tend to rely on forest resources and struggle to guarantee a stable and long-term provision of the minimum resources necessary for physical well-being, such as access to potable water, shelter, and food. The effects of these communities on natural resources have often been considered sustainable, small in scale, or short-lived (temporary). Thus, individually, basic needs communities may be perceived as having minimal impacts on the integrity of the ecosystems they utilize[2]. However, their cumulative impacts can be significant as the number of people living under poverty conditions is estimated to be over a billion and increasing following the 2020 COVID-19 pandemic[3]. On a global scale, it is difficult to measure the extent to which different ecosystems are directly affected by increasing poverty levels and demands for natural resources, which are supplied through subsistence livelihood practices and activities. In turn, we do not know where and which livelihood practices, along with site-specific contextual factors, may result in increased environmental degradation. To address this potential driver of forest loss and degradation, among the target goals of the New York Declaration of Forest, a global environmental agreement to halt and reverse deforestation, sustainable livelihood practices and activities engaged by "basic needs" populations are meant be supported (NYDF)[4]. However, to support these populations and promote sustainable livelihoods, a better understanding of how basic needs livelihood activities and practices are distributed geographically, carried out, and what underlying causes may be resulting in increased forest loss and degradation. Hence, contributing to carbon emissions and climate change through land cover conversion and livelihood-associated carbon footprints[5].

Given the biogeographical distribution of natural resources, as well as cultural diversity, livelihood strategies are site-specific and wide-ranging in scope[5]. In the review by Vedeld *et al*., (2007) of 51 case studies from 17 countries, forest-based products and services represented an average of 22% of the total income, and fuelwood, wild foods, and fodder for livestock were the main resources utilized by these communities[6]. From the extraction of forest-based products to intensive agricultural production systems, basic needs populations both depend on and directly impact natural resources. Hence, changes in livelihood strategies could induce changes in ecosystem dynamics and the services they render. However, the conversion of tropical forest areas driven by basic needs populations is difficult to track, map, measure, and distinguish from other deforestation drivers[7]. The potential negative impacts of these populations are often dismissed as less significant compared to other more obvious, prominent, and lucrative deforestation drivers, such as infrastructure development, agro-industrial activities, and large-scale extraction of timber and other natural resources[8]. In addition, traditional communities living in forested habitats tend to understand natural processes and cycles, and therefore their livelihood practices can be carried out in a sustainable manner[9]. However, when traditional livelihood systems are no longer practiced sustainably, the disturbances to forest resources become more frequent and larger in extent[2]. This is the case with shifting cultivation in eastern Bangladesh. Fallow periods of forest-cleared plots for subsistence agriculture used to be 10-25 years. However, due to population increases along with decreasing available land, fallow periods have been reduced to 2-3 years[10]. This leads to increased soil erosion and impoverishment, and decreased capacity for forests to regenerate. Along with the site-specific nature of livelihoods, site-specific pressures threatening the survival of traditional and local communities need to be better understood to address the aggregated

impacts that basic needs-driven land cover conversion can have.

Given that the true extent of basic needs-driven deforestation and forest degradation is difficult to estimate, so is the carbon footprint of these communities. In general, the degradation and conversion of forest habitat for resources or crop production are associated with a loss of vegetative biomass and, thus, increases in carbon emissions[6,11]. Land use change is responsible for about one third of greenhouse gas emissions[12], and subsistence communities are estimated to be responsible for about a third of that third in developing countries[13]. This accounts for emissions that are relatively lower than other sources. However, to address the anthropogenic drivers of climate change and environmental degradation, different sources and drivers of carbon emissions through land cover change need to be better understood in order to be adequately addressed[14]. Here, we assume that unsustainable changes in the use of forest resources for extractive or production practices by basic needs populations will imply increases in the carbon footprint of these communities. As forest clearing and degradation following the implementation and expansion of different livelihood practices will have different impacts on carbon emissions and, thus, on climate change, exploring which practices are preferred and what may trigger changes would be helpful in assessing the potential carbon footprint of basic needs populations in the tropics.

To advance our understanding of how the livelihoods of traditional and usually considered sustainable basic needs populations become drivers of deforestation and forest degradation, we conducted a systematic review of the literature. The purpose was to identify livelihood activities undertaken by basic needs populations that should be prioritized to reduce forest loss and degradation and, in turn, contribute to climate change reductions. For this purpose, the objectives of the systematic review were: (1) to assess the distribution of commonly known livelihood activities and practices engaged by these communities; and (2) to examine contextual factors as potential underlying causes of forest loss and degradation. We present an overview of basic needs livelihoods and summarize the corresponding contextual factors of the communities reported. Research articles included in this systematic review describe case studies at the community level where deforestation and/or forest degradation were associated with livelihood activities engaged in by basic needs populations in the tropics. This research intends to support the development of effective, sustainable pathways and conservation interventions that target basic needs populations at the forest frontier and that stand at a crossroads between sustainable development and short-lived resource exploitation, which increases a community's vulnerability by diminishing their future capacity for self-resilience.

METHODS

A literature review was conducted following the PRISMA 2020 statement guidance for systematic assessments[15]. While the concept of "basic needs" is commonly used to describe poverty and was implied to define poverty-driven forest loss and degradation by the NYDF multi-stakeholder coalition agreement, it is not often used in the literature to describe subsistence populations. Instead, widely known livelihood activities and practices engaged by basic needs populations for subsistence purposes were identified as search concepts. It was assumed that livelihood practices that were more frequently associated with deforestation and forest degradation would have a greater carbon footprint due to their impacts on land cover change and reductions in carbon stocks.

A non-comprehensive list of livelihood activities and practices was grouped under six umbrella concepts based on the following characteristics (in alphabetical order): (1) animal husbandry, mainly for domestic needs; (2) crop production, which encompasses small-scale farming; (3) fishing, which embraces small-scale fish/crustacean production activities for subsistence or low-volume commercial purposes, for instance in

communities living nearby mangrove forests along coastlines, or using fishponds in humid lowland forests areas; (4) illegal practices, which included the small-scale cultivation of illicit crops and/or the unlicensed extraction of mineral resources; (5) non-timber forest products, which includes the collection of forest products other than timber (e.g., medicinal plants, bush meat) for subsistence purposes; and (6) wood harvest, which includes activities/practices associated with non-mechanized and small-scale wood extraction for various domestic or commercial uses.

Assuming that forest and natural habitats function as atmospheric carbon sinks and storage areas, a relative carbon footprint score (low, medium, and/or high) was assigned based on the potential forest disturbance (clearing and/or degradation) caused through the implementation of the listed livelihood activities [Figure 1]. The generalized and subjective carbon footprint scores (applicable across tropical forest biomes) depict the relative carbon sequestration and stock reductions potential, and thus, associating land cover change with carbon footprint, of scaling and expanding extractive practices and agricultural systems. Three human-induced disturbance criteria were used to qualify the implementation of the livelihood activities near or within forest habitats: (1) relative area required for livelihood activity implementation [small (< 2 ha), medium (between 2 and 10 ha), and/or large (> 10 ha)]; (2) frequency or duration of the activity as a disturbance to forest areas [short (< 1 year), medium (1-3 years), and long-lasting (> 3 years)]; and (3) intensity of the disturbance as per Machado's (2014) Natural Index (NI) adapted into low (NI = 6-10), medium (NI = 3-5), and high (NI = 0-2)[16]. Supporting references as well as the authors' familiarity with the practices in developing countries were used to qualify the livelihood impacts on natural systems. To a lesser extent (as it is difficult to generalize), the activity's potential contributions to greenhouse gas emissions during implementation were also considered but not ranked. For example, the conversion of a forest area into pastureland for cattle ranching is an extensive, likely permanent, and drastic change in land cover, which would be expected to become a net source of carbon emissions rather than a net sink over time[17]. While the actual carbon footprint of a practice or activity requires site-specific analysis, the generalized table serves as a reference to relate the livelihood impacts on forests with their potential carbon footprint contributions to climate change.

In total, 25 practices and activities were combined with the search terms "deforestation" and "forest degradation". The search clauses were used in Scopus and Web of Science™ search engines. Search parameters were set as: *title, abstract,* and *keywords*in Scopus and *topic*in Web of Science (which includes title, abstract, and keywords). All documents written in English, Spanish, or French and published between 2000 and 2019 were considered. Following the PRISMA guidelines, duplicate articles were deleted to avoid double counting, and the review of the output documents and articles was subjected to three screening processes. A first screening was based on a review of the output titles to verify whether the topic and contents of the documents were conducive to the study objectives. A second screening was carried out by reviewing the abstracts according to the following criteria: (1) the documents/article reported deforestation and/or forest degradation impacts caused by basic needs populations related activities/practices; and (2) the document/article described context-related factors and/or socioeconomic characteristics (hereafter referred to as contextual factors) for a specific location and communities. The resulting documents and articles were subjected to full-text review by the authors as a third screening step. Information on livelihood activities/practices engaged by basic needs populations as well as the socioeconomic characteristics that underpin these activities and their relationship with forest resources was collected. To expand the number of case studies, a two-level snowball sampling procedure was applied to the remaining list of publications. At the first level, references cited in the resulting sample were reviewed to identify additional studies. At the second level, references cited by the "additional studies" were reviewed to further expand the subsample for the final analysis.

No.	Umbrella Concept	Basic Needs Livelihood Activity/Practice	Forest Disturbace Criteria									Relative Carbon Footprint Score due to Forest			Support. Ref.
			Area			Duration			Intensity						
			Small (< 0.5 ha)	Med (0.5-2 ha)	Large (> 2 ha)	Short (< 1 year)	Med (1-4 years)	Long (> 4 years)	Low (NI = 6-10)	Med (NI = 3-5)	High (NI = 0-2)	Low	Med	High	
1	Animal husbandry	Cattle ranching		1	1		1	1		1	1	0	3	3	[17]
		Forest livestock grazing		1	1	1	1		1	1		2	3	1	[25]
		Livestock raising	1	1	1		1		1	1		2	3	1	[17]
2	Crop Production	Small-scale agriculture	1	1			1		1	1		2	3	0	[26]
		Subsistence farming	1	1			1		1	1		2	3	0	[27]
		Shifting Cultivation	1	1			1	1	1	1	1	2	3	2	[10, 18, 19]
		Slash and Burn	1	1				1	1	1	1	2	2	2	[20, 21]
		Swidden agriculture	1	1			1	1		1	1	1	3	2	[22-24]
3	Fishing	Aquaculture	1	1	1		1	1		1	1	1	3	3	[28]
		Artisanal fishing	1	1		1	1		1			3	2	0	[29]
		Shrimp farming	1	1			1	1			1	1	2	2	[28]
4	Illegal practices	Artisanal mining	1			1	1		1			3	1	0	
		Coca cultivation	1	1		1	1		1	1		3	3	0	[30]
		Illicit crops	1	1		1	1		1	1		3	3	0	[31]
		Informal mining	1	1				1		1	1	1	2	2	[32, 33]
5	Non-Timber Forest Products	Honey	1			1			1			3	0	0	[34]
		Hunting	1	1	1	1	1		1	1		3	3	1	[18]
		Medicinal plants	1			1			1	1		3	1	0	-
		Resin Tapping	1			1			1			3	0	0	
6	Wood Harvest	Biofuel		1	1		1	1		1	1	0	3	3	
		Charcoal	1	1	1	1	1	1		1	1	2	3	3	[28, 51]
		Cooking	1	1		1	1		1	1		3	3	0	
		Firewood	1	1	1	1	1		1	1	1	3	3	2	
		Fuelwood	1	1	1	1	1		1	1	1	3	3	2	[7, 52]
		Wood collection	1	1		1	1		1	1		3	3	0	

*The assigned carbon footprint scores or score gradients were based on the relative loss of carbon stock due to forest clearing and degradation during livelihood production or extraction processes. Three anthropogenic disturbance assessment criteria were used: (i) relative area requirements to carry out the livelihood practice; (ii) frequency or duration of activity as a disturbance to forest areas; and (iii) intensity of disturbance for the livelihood to be carried out. The authors' understanding and familiarity with the various practices and their impacts on forest and natural habitats, as well as supporting references, were used to qualify each criterion. Practices that result in severe and long-lasting changes in vegetation were scored with "high" impact values (red) *vs.* practices that result in "low" changes in land cover (green). Mid-scale land cover impact practices were scored as "medium" (yellow). Depending on how practices are implemented, a relative carbon footprint score could be expected across the impact gradient (green, yellow, and red scores for low, medium, and high, respectively). These "guesstimates" will vary depending on various site-specific characteristics and management levels. Despite their inherent weaknesses, the arbitrary scoring values are presented to raise awareness of the issue and stimulate discussion and future research on improving them. **Two additional concepts (migration agriculture and Taungya systems) were included in the original search but not listed as no outputs referred to these.

Figure 1. Contextual factors most frequently reported by the reviewed case studies when describing basic needs populations and deforestation and forest degradation. Both qualitative evidence (e.g., observations) and quantitative information (i.e., statistically tested), as reported by the output articles, were used to define the relationships among context-related factors, livelihoods, and forest disturbance.

The information presented by the case studies was collected in a tabular manner through a matrix table. Different parameters were searched for in each case study, which included the geographical location, the number of communities examined, the livelihood practices/activities described for each community, and a total of 12 contextual factors. The list of contextual factors included information on changes in: (1) population pressure; (2) household size; (3) land tenure; (4) level of education; (5) alternative labor; (6) migration; (7) forest access; (8) market access; (9) governance; (10) access to technology; and (11) social capital. The frequency in which the studies described these parameters and contextual factors was summarized and compared in the results through descriptive statistics.

RESULTS

The systematic review and search clause combinations resulted in 2200 outputs (after the removal of duplicates). The first and second screenings greatly reduced the number of documents resulting in a subsample of 462 and 147 outputs, respectively. The screened documents and articles were fully reviewed as a third screening process and to collect both qualitative (e.g., unstructured interview data or observations by authors) and quantitative (e.g., obtained through statistical analyses) information on the relationship between socioeconomic variables and basic needs livelihood activities driving deforestation and/or forest degradation. Through this process, the majority (63%) of the articles were discarded as they did not provide case study information. The systematic search resulted in a total of 54 articles. The following two-level snowball process yielded 47 additional documents, resulting in a final sample of 101 articles [Figure 2 and Supplemental Materials].

Distribution of basic-needs livelihoods

Of the resulting articles (101), the characteristics of 161 different communities were described as case studies within 39 countries [Figure 3]. All the articles described case studies located in Africa, Asia, or Latin America and the Caribbean (LAC) and, except for Azerbaijan and South Africa, in countries considered tropical according to the Food and Agriculture Organization[18]. Most of the research articles described cases in Africa (39), followed by Asia and LAC (33 and 29, respectively). At the country level, India had the highest number of articles (12), followed by Brazil (9), Uganda (8), Peru (6), Ethiopia (5), and Indonesia (5). As sources of income, the list of activities and practices in Figure 1 were reported a total of 275 times by the 161 case study communities. This means that a large percentage (85%) of the communities described relied on more than one subsistence livelihood activity. Most practices were reported in Asia-based communities (128), followed by Africa (98) and LAC (49).

From the results, the umbrella concept themes for wood harvest and crop production contained the most common basic needs livelihood activities engaged by the communities (106 and 91 times, respectively). When compared by continent [Figure 4], wood harvest was more common in Africa (45%), while small-scale crop production was more often associated with LAC communities (43%). Wood harvest was slightly higher than crop production in Asia (35% *vs.* 30%) but even more comparatively in Africa (45% *vs.* 32%) and LAC (35% *vs.* 43%). As per other umbrella concept themes, the results show that roughly 27% (43) of the case studies reported negative forest impacts caused by the collection of non-timber forest products (NTFPs). Of these, more studies were reported in Asia (26) than in the two other geographical regions (13 in Africa and 4 in LAC). About 12% (20) of the case studies addressed animal husbandry as an activity undertaken by basic needs populations, which was associated with deforestation and degradation when conducted inside forests. Finally, a limited number of studies discussed fishing activities and illegal practices (crops and mining). Illegal practices were disaggregated as no case studies for coca cultivation or illicit crops were identified for Asia. From here on, we refer to illegal mining activities (including artisanal and informal) as "illegal mining" and illegal crop growing activities (including coca cultivation) as "illicit crops". For these two themes (fishing and illegal practices), the few case studies describing these livelihood activities provide limited insights into their potential impacts on deforestation and forest degradation in this review.

Contextual factors and potential deforestation implications

While subsistence livelihood activities may be carried out in a sustainable manner, Figure 5 provides an overview of contextual factors reported by authors that may influence the relationship between basic needs populations and forest loss. Changes in population pressure through increased population size were the most frequently reported contextual factor mentioned in 113 of the case studies reviewed. In addition to population pressure, the availability of alternative labor options and land tenure-related issues were also frequently mentioned (107 and 88 times, respectively) among the top three contextual factors influencing

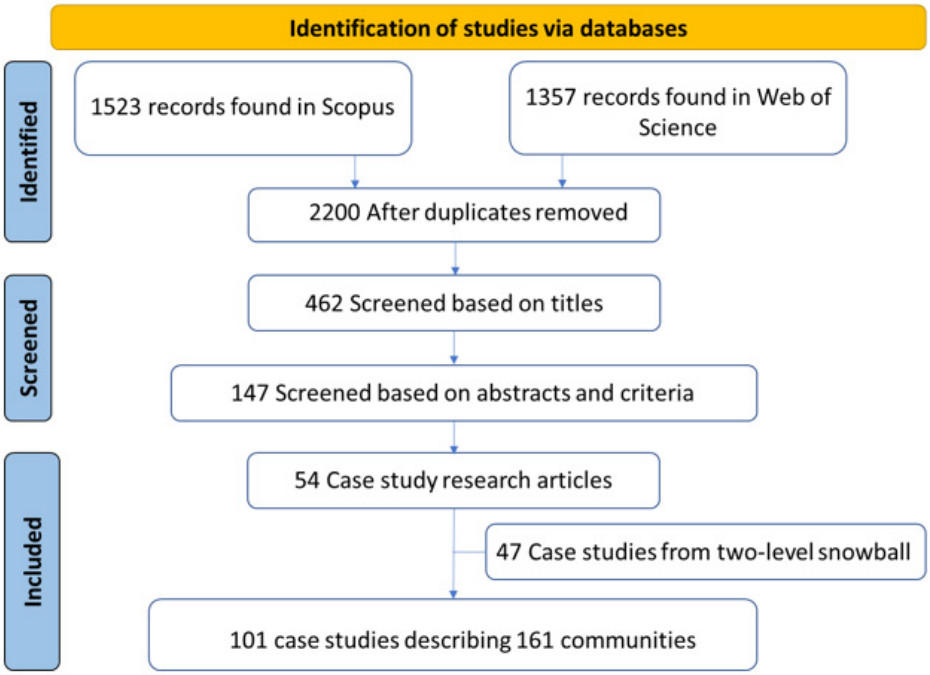

Figure 2. Flow diagram of the systematic review process followed to select research publications (adapted from PRISMA 2020)[15].

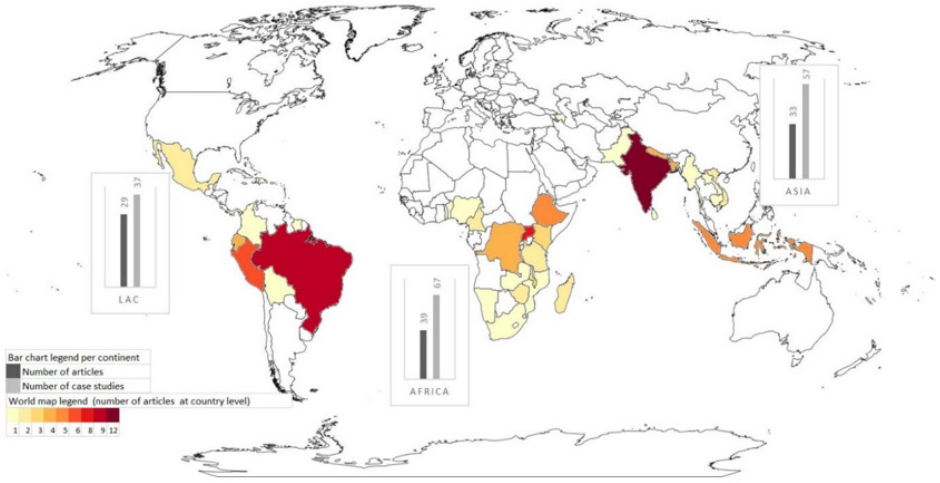

Figure 3. Distribution of the articles and case studies identified through the literature review on basic needs activities and practices associated with deforestation and/or forest degradation.

land use practices and incidental forest impacts. The next most common contextual factor with 67 mentions was the presence and/or access to markets for selling forest-extracted or agricultural products.

As fifth in this list, the accessibility to forest resources was in consensus associated with deforestation in 65 communities. Education was mentioned 63 times with a variety of impacts on forest resources. Governance, which encompasses the political context and is related to resource management and land tenure, was reported in 59 communities. In terms of household size, the composition of households was described in 58 communities, and, in general, a higher number of household members was attributed to greater

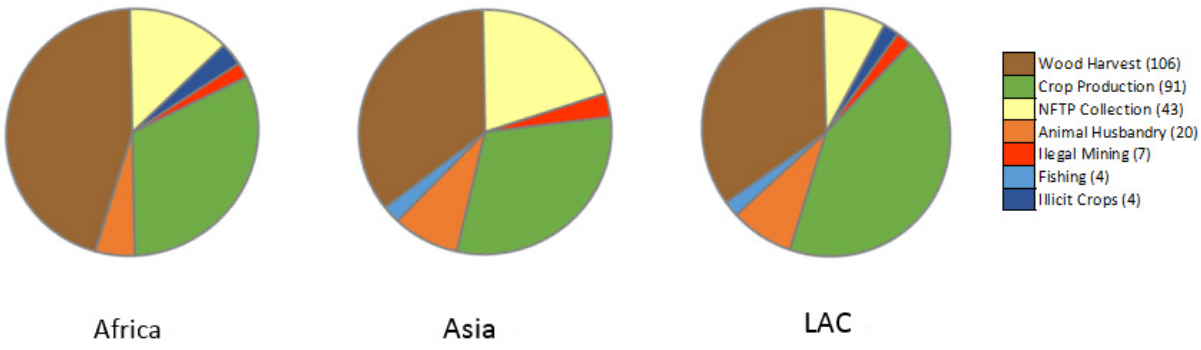

Figure 4. Livelihood activities and practices engaged by basic needs populations associated with deforestation and forest degradation broken down by geographical region and described using the umbrella concept themes. Numbers in parentheses correspond to the total number of case studies that reported a given activity/practice under that theme.

deforestation. However, there were case studies where a higher number of family members (that often included several generations) were described to result in a lower demand for resources as these were shared in the household[19]. Some studies also described how household composition (males *vs.* females) could influence forest impacts. On the opposite end, access to farming inputs and technology, social capital, and migration (mentioned 15, 16, and 31 times, respectively) were the least frequently mentioned contextual factors when describing the relationship between basic needs livelihoods and deforestation.

DISCUSSION

Basic needs livelihoods

Agriculture, for both commercial and subsistence purposes, is a direct and major driver of deforestation, estimated to be responsible for about 80% of forest loss worldwide[20,21]. However, the impact of subsistence communities on deforestation and forest degradation is difficult to determine at regional and global scales. To overcome the lack of available data and to distinguish between commercial and subsistence agricultural impacts, Hosonuma *et al.*, (2012) aggregated country-level information by summarizing REDD+ readiness-related data (along with other sources)[13]. From their results, agriculture was estimated to be responsible for 73% of deforestation, which is close to the previously mentioned estimate. However, more interestingly, from their findings, an approximate value of 33% of deforestation is attributed to subsistence agriculture. Given the significance of this estimated negative impact, and to expand our understanding of the relationship between subsistence agricultural and forest loss, this review assesses the livelihood practices and activities more frequently engaged in by basic needs populations and characterizes frequently mentioned contextual factors as potential underlying causes of deforestation and forest degradation.

With a similar objective but mainly focused on cash crop production systems and extraction activities, Boucher *et al.*, (2011) examined commercial and subsistence drivers of deforestation and forest degradation[5]. In their review, they concluded that agriculture- and extraction-based drivers of deforestation vary greatly between continents. For example, cattle ranching and large-scale agriculture are major drivers of deforestation in Latin America, whereas palm oil and pulp and paper plantations are principal drivers in Indonesia. While the distribution of basic needs populations is widespread throughout the tropics and sub-tropics, the livelihood practices of these communities are closely dependent on the services and benefits obtained from natural resources[22,23]. From the results, wood harvest and crop production were the umbrella themes more frequently mentioned when associating basic needs populations with forest loss. Small-scale crop production systems were more often associated with LAC countries, while wood harvesting activities were more commonly reported in African communities. Depending on how these activities are carried out,

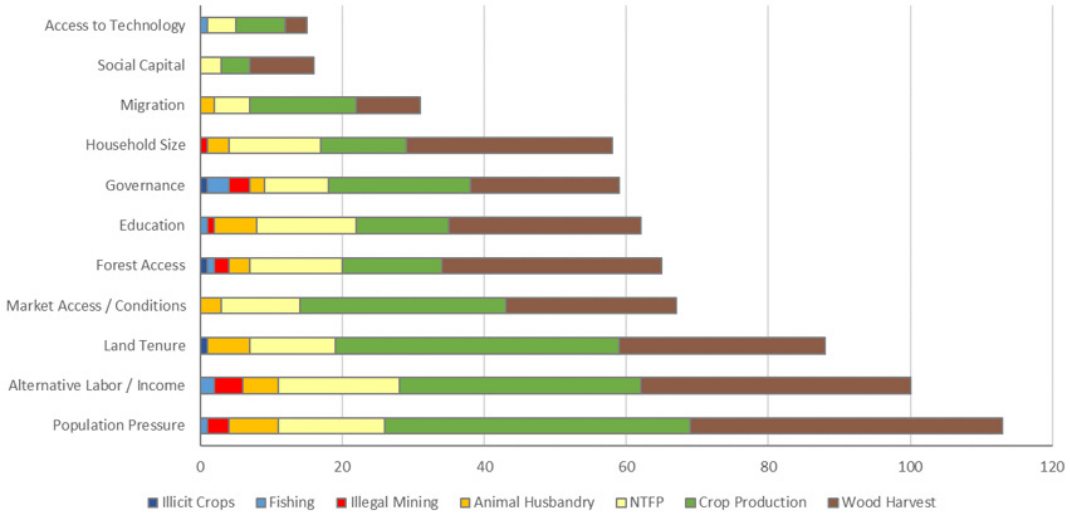

Figure 5. Contextual factors most frequently reported by the reviewed case studies when describing basic needs populations and deforestation and forest degradation. Both qualitative evidence (e.g., observations) and quantitative information (i.e., statistically tested), as reported by the output articles, were used to define the relationships among context-related factors, livelihoods, and forest disturbance.

their carbon footprint impacts can range from low to high. Compared to crop production, if wood harvesting is practiced sustainably by collecting dead and dry biomass, it can be considered less destructive to forest habitats as opposed to land cover conversion required in agricultural production[5]. Under the wood harvest theme, previous research describes fuelwood collection and charcoal production as less environmentally harmful and prevalent basic needs activities in African countries compared to other continents[13,20]. However, if wood is not harvested sustainably, not only carbon emissions are generated through environmental degradation but also through greenhouse gas emissions during the incomplete combustion of biomass[24].

In their executive summary, Boucher *et al.*, (2011) stated that the aggregated impacts of small-scale farming and firewood collection are low and decreasing compared to commercial practices[5]. While other researchers would agree that the relative impact of industrial agricultural activities on forest is not only larger but should be the main targeted sector to reduce deforestation[21], the slow, scattered, and sometimes unnoticeable impacts of subsistence communities on forest, and thus on wildlife and climate change, is often overlooked, especially since reducing the impacts by basic needs populations on deforestation will be more challenging than targeting commercial operations[25]. While commercial agriculture and extraction activities should certainly be made more accountable, as well as other drivers of deforestation, the cycles of poverty-driven deforestation and its aggregated carbon footprint through land cover conversion need to be addressed. Basic needs communities contribute to and are affected by diminishing natural resources and climate change impacts. However, it is not about pointing fingers but providing additional supporting arguments to lift these communities from poverty cycles to reduce deforestation and forest degradation, in turn, mitigating climate impacts[9,14].

In the case of animal husbandry, owning and raising animals usually reflects relatively greater status or financial resources, as well as access to land and/or means to manage it[2,26]. Hence, the practice is not usually associated with subsistence communities but with agribusiness or wealthier farmers for commercial purposes. This may explain why in the present literature review, fewer case studies were identified relating livestock grazing to deforestation and forest degradation. However, livestock grazing for subsistence

purposes has been a common practice by traditional communities that share land and/or manage pastures[27]. In the case of forest livestock grazing, the practice is opportunistic, where farmers allow their herds to graze in available forest areas, which could lead to forest degradation. However, forest grazing has been practiced for centuries in temperate forests, and while some claim negative impacts on natural ecosystems[28], others see the traditional practice in a more positive light[29]. In general, non-commercial animal husbandry managed in a sustainable manner can render many benefits to subsistence farmers while having a relatively lower carbon footprint.

Livelihood practices such as fishing and illegal practices (crop and/or mining) are activities constrained by predisposing environmental and biogeographical conditions, such as the presence of mangroves, flooding areas, remote and clandestine locations, and/or the availability of mineral resources. The implementation of these livelihood practices among basic needs populations is in large part limited to biophysical factors. However, other context specific implications are relevant for the legal and proper engagement of subsistence communities in these practices. In addition to technical capacities and financial resources, management plans or permits may be required to carry out these activities[30]. However, when conducted illegally, informal markets or trafficking networks need to be established to mobilize the products to distributors, traders, and end users[31]. Thus, while these types of subsistence livelihood practices were not common or widespread according to the present review, they could lead to severe environmental disturbances while also having relatively lower carbon footprints[31,32].

Contextual factors

To help understand how basic needs communities affect forest resources, a closer look at the contextual factors in which these communities exist may provide insights into the underlying causes that render otherwise sustainable livelihood practices into deforestation drivers. The present systematic review identified the most frequently mentioned contextual factors and socioeconomic characteristics described by authors when relating changes in forest resources to basic needs livelihood practices. When changes in population size were described, in all reported cases, the authors referred to increases in population as the most relevant underlying cause of forest loss by basic needs communities. While population growth was described in some communities as rapid compared to others and thus having greater negative impacts in those locations, the implication is that population growth increases the pressures on land and forest resources, which results in shorter fallow periods, soil nutrient depletion, and land degradation[33].

When it comes to alternative labor, the results are not straightforward. On the one hand, more job opportunities and income sources could result in a reduction in forest loss and degradation[34]. On the other hand, those jobs could be contributing to the continued dependency and degradation of forest habitats[9]. However, what came across clearly is that when alternative livelihood opportunities were sustainable or involved the protection of natural resources, these promoted the conservation of forests and natural habitats[35]. This will also be the case with access to markets and technology. When these contextual factors have clear objectives to promote forest conservation, as in the case of gas stoves used to reduce the dependency on fuelwood, deforestation and forest degradation will tend to decrease while improving human wellbeing[36]. However, for the creation of conservation-focused and sustainable alternative livelihoods, a series of support structures are required. A lack or weakness in any given community-support area (e.g., organizations that provide clear governance, social capital, and/or economic institutions) would represent a limiting factor needed to be overcome to guarantee the sustainable development of marginalized communities[37].

Government organizations are expected to aid and secure the needs and rights of their citizens, especially in the case of isolated and vulnerable communities. The public sector is responsible for establishing policies and regulations, implementing them through accomplishable plans and programs, and enforcing their compliance through effective monitoring mechanisms and inspection agencies. At the forest frontier of many tropical countries, governments need to guide the path towards achieving sustainable development. Relevant contextual factors could provide insights on what issues to prioritize in the design of sustainable development programs targeting basic needs populations for deforestation reductions and climate mitigation. In addition to addressing population pressure through the promotion of sustainable labor alternatives, land tenure rights and territorial zoning are key governance issues to manage and control land cover change and promote climate-smart production practices[5]. Given that country pledges are not on track in meeting their global environmental commitments to halt deforestation, which contributes to climate change mitigation and biodiversity loss reductions, it is necessary for other stakeholders to support government efforts in overcoming these challenges[3]. For their own operational viability, as well as for accountability and reputational risks, the private sector is starting to recognize their pivotal role in avoiding deforestation caused by their supply chains, which in the tropics often involves small and subsistence land holders[38,39]. As economic development and rural expansion reach subsistence communities at the forest frontier, basic needs populations are incorporated into markets through the commercialization of value chains and resource extraction. While not across case studies[40], the consensus was for greater market accessibility to be followed by greater forest degradation[41]. However, this could be avoided through incentive mechanisms and impact-focused financial instruments, interested in transforming economic development at the forest frontier[42]. Private sector and financial institutions can be a game-changer by promoting forest-based products, agroforestry systems, restoration activities, and innovation that could generate lucrative financial returns, in addition to social and environmental ones[43].

Limitations and key insights

Accurately assessing carbon footprint and climate change impacts from deforestation driven by poverty may be an impossible task. There are limitations in the literature available for the application of methodological approaches that would allow for the comprehensive mapping of basic needs communities, the estimation of their carbon footprint impacts through land cover change, and the monitoring of contextual factors affecting the implementation of livelihood practices and activities. Hence, the present systematic literature review represents an effort to assess a fixed and non-comprehensive list of livelihood practices and activities. Nonetheless, the review provides interesting insights on what, where, and why subsistence livelihood practices may be triggered to become less sustainable. As is often the case with environmental issues, there are no silver bullet solutions or single sectors to be targeted to reduce deforestation and greenhouse gas emissions to mitigate climate change. There are multiple development pathways in which livelihoods and contextual factors characterize and mold human communities within distinct geographical and environmental settings. Numerous efforts and various stakeholders need to be engaged to address the different drivers of deforestation. In the case of basic needs populations, their carbon footprint usually dwarfs that of other populations with higher consumption rates. Given their significance in numbers and direct dependence and impact on natural resources, subsistence populations need to be supported to ensure they can develop and excel. Low emissions livelihood activities that are economically viable, as well as environmentally responsible and that include the protection of natural resources, should be promoted. Without these provisions and safeguards, basic needs populations will be bound to continue to engage in deforestation and environmental degradation activities in order to survive, resulting in a reduction in implied carbon stocks.

DECLARATIONS

Authors' contributions

Conceived and design of the study: Francesconi W
All the authors performed data analysis and interpretation: Francesconi W, Bax V, Vanegas M
Performed data acquisition, management, and figure design: Vanegas M, Bax V
Provided administrative support: Francesconi W

Availability of data and materials

The list of articles that resulted from the systematic review can be found in the Supplementary Materials section.

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Conflicts of interest

All authors declare there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

REFERENCES

1. UNDP (United Nations Development Programme). Human development report 1990. Oxford University Press: Oxford. 1990.
2. Pacheco P. Smallholder livelihoods, wealth and deforestation in the Eastern Amazon. *Hum Ecol* 2009;37:27-41. DOI
3. Progress on the New York declaration on forests. Taking stock of national climate action for forests. Goal 7 progress report October 2021. Available from: https://forestdeclaration.org/ [Last accessed on 11 Oct 2022].
4. Goal 4 assessment technical annex to the five-year assessment report. 2019. Available from: https://forestdeclaration.org/wp-content/uploads/2020/11/2019NYDFGoal4.pdf [Last accessed on 17 Oct 2022].
5. Boucher D, Lininger K, May-Tobin CC, Saxon E. The root of the problem: what's driving tropical deforestation today? Available from: https://www.researchgate.net/publication/285811686 [Last accessed on 11 Oct 2022].
6. Vedeld P, Angelsen A, Bojö J, Sjaastad E, Kobugabe Berg G. Forest environmental incomes and the rural poor. *For Policy Econ* 2007;9:869-79. DOI
7. Hoffmann C, García Márquez JR, Krueger T. A local perspective on drivers and measures to slow deforestation in the Andean-Amazonian foothills of Colombia. *Land Use Policy* 2018;77:37991. DOI
8. Godar J, Gardner TA, Jorge Tizado E, Pacheco P. Actor-specific contributions to the deforestation slowdown in the Brazilian Amazon. *Proc Natl Acad Sci USA* 2014;111:15591-6. DOI
9. Bong IW, Felker ME, Maryudi A. How are local people driving and affected by forest cover change? *PLoS One* 2016:11. DOI PubMed PMC
10. Rahman SA, Rahman MF, Sunderland T. Causes and consequences of shifting cultivation and its alternative in the hill tracts of eastern Bangladesh. *Agroforest Syst* 2012;84:141-55. DOI
11. Lal R, Smith P, Jungkunst HF, et al. The carbon sequestration potential of terrestrial ecosystems. *J Soil Water Conserv* 2018;73:145A-152A. DOI
12. Lal R. Reducing carbon footprints of agriculture and food systems. *Carbon Footprints* 2022;1:3. DOI
13. Hosonuma N, Herold M, de Sy V, et al. An assessment of deforestation and forest degradation drivers in developing countries. *Environ Res Lett* 2012:7. DOI
14. Skutsch M, Turnhout E. REDD+: if communities are the solution, what is the problem? *World Dev* 2020:130. DOI
15. Page MJ, Mckenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*

2021;372:n71. DOI
16. Machado A. An index of naturalness. *J Nat Conserv* 2004;12:95-110. DOI
17. Bustamante MMC, Nobre CA, Smeraldi R, et al. Estimating greenhouse gas emissions from cattle raising in Brazil. *Clim Chang* 2012;115:559-77. DOI
18. Food and Agriculture Organization of the United Nations. Forest resources assessment 1990. FAO forestry paper 112. Food and Agriculture Organization of the United Nations: Rome, Italy. 1990.
19. Amare D, Mekuria W, Wondie M, Teketay D, Eshete A, Darr D. Wood extraction among the households of zege peninsula, northern ethiopia. *Ecologic Econom* 2017;142:177-84. DOI
20. Geist HJ, Lambin EF. What drives tropical deforestation? A meta-analysis of proximate and underlying causes of deforestation based on subnational case study evidence. University of Louvain: Belgium..
21. Kissinger G, de Sy V. Drivers of deforestation and forest degradation: a synthesis report for REDD+ policymakers ESA worldcover view project BACI: detecting changes in essential ecosystem and biodiversity properties-towards a Biosphere atmosphere change index view project. Available from: https://www.researchgate.net/publication/283069190 [Last accessed on 11 Oct 2022].
22. Rudel TK. Changing drivers of deforestation and new opportunities for conservation. *Conser Biol* 2009;23:1396-405. DOI PubMed
23. Roser M, Global extreme poverty. Available from: OurWorldInData.org [Last accessed on 11 Oct 2022].
24. Bailis R, Drigo R, Ghilardi A, Masera O. The carbon footprint of traditional woodfuels. *Nat Clim Chang* 2015;5:266-72. DOI
25. Shearman PL, Ash J, MacKey B, Bryan JE, Lokes B. Forest conversion and degradation in Papua New Guinea 1972-2002. *Biotropica* 2009;41:379-90. DOI
26. Marulanda LP, Lavelle P, Jepsen MR, et al. Farmscape composition and livelihood sustainability in deforested landscapes of colombian amazonia. *Agriculture* 2020;10:1-20. DOI
27. Kikoti IA, Mligo C. Impacts of livestock grazing on plant species composition in montane forests on the northern slope of Mount Kilimanjaro, Tanzania. *Int J Biodivers Sci Ecosyst Serv Manag* 2015;11:114-27. DOI
28. Dennis A. Effects of livestock grazing on forest habitats. In: Schwartz MW, editor Conservation in Highly Fragmented Landscapes. Springer: Berlin/Heidelberg. 1997.
29. Varga A, Demeter L, Ulicsni V, et al. Prohibited, but still present: local and traditional knowledge about the practice and impact of forest grazing by domestic livestock in Hungary. *J Ethnobiol Ethnomed* 2020:16. DOI PubMed PMC
30. Santos LCM, Matos HR, Schaeffer-Novelli Y, et al. Anthropogenic activities on mangrove areas (São Francisco River Estuary, Brazil Northeast): a GIS-based analysis of CBERS and SPOT images to aid in local management. *Ocean Costal Manag* 2014;89:39-50. DOI
31. Dávalos LM, Sanchez KM, Armenteras D. Deforestation and coca cultivation rooted in twentieth-century development projects. *Bioscience* 2016;66:974-82. DOI
32. District G, Zimbabwe Bhebhe ZD. A case study of t case study of t he perceived socio he perceived socio-environmental problems environmental problems c c Au Au sed by illegal gold sed by illegal gold mining mining in in gwanda district. Volume 6. 2013. Available from: https://www.researchgate.net/publication/259067230 [Last accessed on 11 Oct 2022].
33. Grogan K, Birch-Thomsen T, Lyimo J. Transition of shifting cultivation and its impact on people's livelihoods in the miombo woodlands of northern zambia and south-western tanzania. *Hum Ecol* 2013;41:77-92. DOI
34. Wyman MS, Stein TV. Modeling social and land-use/land-cover change data to assess drivers of smallholder deforestation in Belize. *Appl Geogr* 2010;30:329-42. DOI
35. Win ZC, Mizouec N, Ota T, et al. Differences in consumption rates and patterns between firewood and charcoal: a case study in a rural area of Yedashe Township, Myanmar. *Biomass Bioenergy* ;109:39-46. DOI
36. Progress on the New York declaration on forests support alternative livelihoods. 2022. https://forestdeclaration.org/wp-content/uploads/2021/10/2021NYDFReport.pdf [Last accessed on 17 Oct 2022].
37. Scoones I. Sustainable rural livelihoods: a framework for analysis. Institute of Development Studies: Brighton, UK. 1998.
38. Mohammed D, Asamoah D, Asiedu-Appiah F. Cocoa value chain-implication for the smallholder farmer in Ghana. Kwame Nkrumah University of Science & Technology: Ghana, 2011.
39. Malan BB. Reconfiguration of the cocoa industry and poverty reduction in cote d'ivoire reconfiguration of the cocoa industry and poverty reduction in cote d'ivoire 1. 2014. Available from: https://www.researchgate.net/publication/271706319 [Last accessed on 11 Oct 2022].
40. Dash M, Behera B, Rahut DB. Determinants of household collection of non-timber forest products (NTFPs) and alternative livelihood activities in Similipal Tiger Reserve, India. *For Policy Econ* 2016;73:215-28. DOI
41. Thanichanon P, Schmidt-Vogt D, Messerli P, Heinimann A, Epprecht M. Secondary forests and local livelihoods along a gradient of accessibility: a case study in northern laos. *Soc Nat Resour* 2013;26:1283-99. DOI
42. Sitawi. Investimento de impacto na amazônia: caminhos para o desenvolvimento sustentável apoio realização. https://info.sitawi.net/investimentodeimpactoamazonia [Last accessed on 17 Oct 2022].
43. Environmental Finance 2020. Fund of the year - multi-asset/other: Althelia Biodiversity Fund Brazil. Available from: https://www.environmental-finance.com/content/awards/impact-awards-2020/fund-of-the-year-multi-asset/other-althelia-biodiversity-fund-brazil.html [Last accessed on 11 Oct 2022].