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How do trees outside forests contribute to human wellbeing?
A systematic review from South Asia

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Supplementary material for this article is available [online](#)

Abstract

Trees have emerged as a key focus of global environmental policy. Several programs promote planting of trees outside forests (ToF), in places such as farms and grazing lands, due to the potential of trees to provide a wide variety of benefits to people and nature. Yet, our knowledge of human well-being outcomes of ToFs is limited, especially in South Asia. In this systematic literature review, we examine multidimensional human wellbeing outcomes of a wide range of ToF practices in rural landscapes of South Asian countries; including Bangladesh, India, Nepal, Pakistan and Sri Lanka. Relying on six databases, we uncover a large body of research in 325 articles considered for this review. Articles from Bangladesh and India dominate our review, with 71% of the studies. Further, two ToF systems, tree and forest gardens and multipurpose trees on farms, were the most commonly studied, accounting for approximately 43% of the dataset. About 62% of publications reported increases in incomes, representing economic wellbeing, 34% and 36% of publications reported an increase in material wellbeing (access to biomass and fuelwood respectively), and 10% in dietary diversity. ToF systems also created opportunities for vocational training. Trade-offs include negative and mixed outcomes on people's sense of agency, political voice, and social equity in particular with afforestation and monoculture plantation projects in which governmental agencies took leadership or influential roles. Some research designs were weak and it was unclear whether the studied tree-based systems reflect the actual distribution of tree-based systems in

South Asia. This review offers useful insights to guide ongoing and future tree-based natural-climate solutions projects in the region and worldwide to ensure ecological security and human wellbeing are well considered. It also points to areas where future research is needed.

1. Introduction

Over the past decade, trees have emerged as an integral part of leading natural climate solutions (NCS) to mitigate rising atmospheric CO₂ levels [1–3], combat desertification and reach land degradation neutrality [4, 5]. In the UN Decade on Restoration, ambitious global programs such as the Bonn Challenge [6] and the Trillion Trees Campaign [7] promote tree-based carbon enrichment through trees outside existing forests, in places such as farms, backyards, and grazing lands [8, 9]. Targeted interventions aside, many landscapes have substantial trees outside of forests (ToF) that local people already take care of and that provide diverse benefits. ToF, a concept predominantly used in the context of remote sensing of tree cover at fine scales, refers to natural ecosystems with sparse tree cover, such as shrublands and savannas, or human altered tree-based production systems of different densities, such as alley cropping, agroforestry, silvo-pastoralism or woodlots [10]. ToF typically refers to those trees outside government-owned and managed forest land. Besides supplying agricultural and forestry commodities and displaying cultural values, ToF systems can provide supporting and regulating ecosystem services beneficial to people, such as water and soil conservation, microclimate regulation, and natural resources for consumption or sale [11, 12]. However, we have a limited understanding of the multidimensional human wellbeing outcomes of ToF [13, 14], especially in regions like South Asia, which is the focus of this systematic review.

Human wellbeing has multiple dimensions, including economic, educational, social, health and material outcomes [15]. Previous research on ToF has predominantly focused on economic outcomes, with little attention to other human wellbeing outcomes, such as access to food or recreational spaces, or the improvement or deterioration of interactions within a community. For example, large tree plantations frequently provide benefits to people in the form of complementary livelihoods, such as resin tapping and plantation management [16]. A global meta-analysis found that adding trees to farms through different agroforestry practices can increase yields and income for farmers, albeit with substantial variations in these gains [17]. On the other hand, increasing

tree cover outside existing forests can be detrimental to some human wellbeing dimensions. Tree planting activities in Northern India negatively impacted pastoralist communities through reduced access to grazing lands and land closures [18]. In Cambodia, while introducing trees on shifting cultivation lands through a tree planting program provided jobs to local people, far more households were dispossessed of their land due to this program [19]. An unprecedented number of tree-based restoration efforts are taking place, for instance, under the UN Decade on Ecosystem Restoration [13, 20], while there is an increasing recognition that human dimensions of restoration are essential to the success of related efforts [21–23]. Thus, it is crucial to understand the wide range of wellbeing outcomes, both negative and positive, of ToF, and the conditions under which these outcomes are observed, to inform ongoing and future tree planting programs or other policy interventions and to better support people in the care and management of ToF already present in their landscapes.

Human wellbeing outcomes of ToF are understudied in South Asia, although the region includes countries with some of the largest global tree restoration potential [1]. The region has strong cultural norms of ToF practices, such as using live fences and multistoreyed cropping systems in small-scale agriculture [24, 25]. Moreover, South Asian countries such as India and Bangladesh have large restoration targets and intend to restore 8.74% or 26 mha [23] and 5.76% or 0.75 mha [24] of their land surface by 2030, respectively. The lack of South Asian studies in previous literature reviews on ToF [11, 16, 17] presents a substantial knowledge gap on the human wellbeing outcomes of ToF in this region. Importantly, not addressing this gap could potentially make tree planting and forest restoration campaigns ineffective, since they will be unable to fully integrate wellbeing outcomes of ToF, which are an important aspect of these densely populated nations meeting their climate mitigation pledges [26, 27].

This study systematically reviews the human wellbeing outcomes of a wide range of ToF in rural landscapes in five South Asian countries: Bangladesh, India, Nepal, Pakistan and Sri Lanka. Specifically, we

asked the following question: *What are the multidimensional human wellbeing outcomes of ToF in South Asia?*

2. Methods

2.1. Systematic review framework and protocol

This systematic review is reported according to the RepORting standards for systematic evidence syntheses standards [28] (see appendix 1). We follow the PICO (Population, Intervention, Comparator, Outcomes) framework [16]. *Population* refers to the subjects included in a particular intervention. *Intervention* refers to the treatment, which could be a management practice or policy or any action. *Comparator* indicates the control group for the study. Lastly, *outcomes* refer to the specific impacts/ outcomes for the population (table 1). Prior to beginning this review, we registered our systematic review protocol on the PROCEED database following the peer review process [29].

2.2. Eligibility criteria

We restricted our geographic search to the following countries: India, Sri Lanka, Bangladesh, Pakistan and Nepal. We considered observational and quantitative (quasi-) experimental or impact evaluation studies in peer-reviewed literature. We excluded theoretical or modeling peer-reviewed studies as they do not have primary data to include. We only reviewed English-language articles accessible to the University of Minnesota libraries and through Interlibrary loans. We did not incorporate any restrictions on the year of publication.

2.3. Human wellbeing outcomes

In the context of this systematic review, we use the term human wellbeing, to include the following components: material and living standards, health, education, work and leisure, agency and political voice, social relationships, physical and economic security (as defined by Rogers *et al* [15]; figure 1; table S1).

2.4. Search terms

A science librarian and subject matter expert developed a comprehensive search strategy using three literature reviews [15, 30, 31] related to trees on farms and ToF to develop our list of outcomes and our search terms. Appendix II provides the full search strategy developed for our main database including more details of the terms used for ToF systems considered in this study and the different terms used for the wellbeing outcomes we considered. Table S3 provides an example of the search terms used in the CAB Abstracts database.

2.5. Search strategy

We reviewed six databases—CAB Abstracts via Ovid, Agricola via Ovid, Scopus via Elsevier, Web of Science: Core Collection via Clarivate, EconLit via Proquest, Agricultural and Environmental Science Database via Proquest—(figure 2), in which we identified 9836 articles that we imported in Covidence [32]. We discarded 3873 articles that were duplicates. The remaining 5963 articles were screened based on the title and abstract. First, we selected a random set of 50 search results to be screened by each of the reviewers to check the level of agreement among the reviewers. After a consistency check, each article had two reviewers independently screening it to determine the appropriateness of the result in this review. Upon agreement between the assigned two reviewers on a particular article, the article moved to the full-text screening stage, where another two independent reviews were carried out. We screened the full text of 912 articles.

During both title and abstract screening and full-text screening stages, when there was a disagreement amongst the two reviewers, the article was reviewed by a third reviewer. The vote of this third reviewer was considered the final vote. On completing the full-text screening, we downloaded the final set of publications ($N = 325$ articles) to be included in the review from Covidence as a .csv file to code and analyze it.

2.6. Data coding

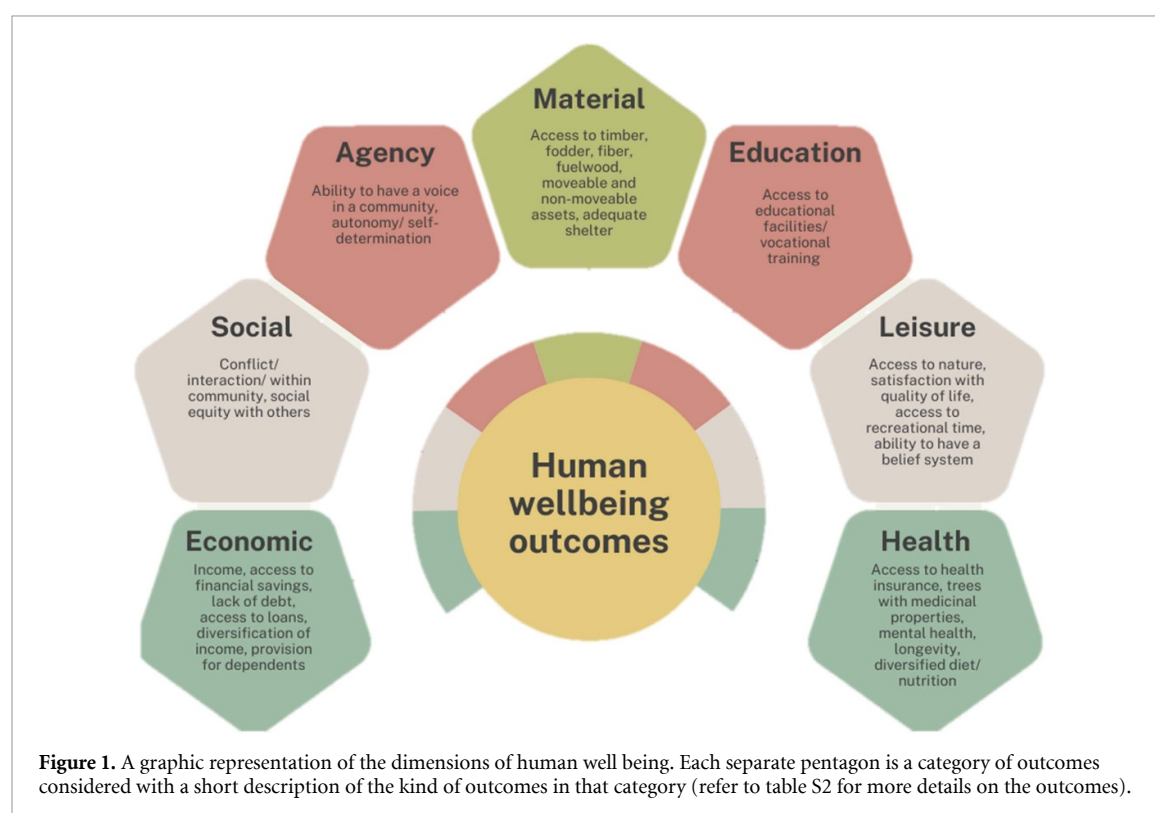
We used a standardized survey in Qualtrics [33] to code the data from the final set of 325 publications considered in this review. Each publication had two coders, one primary and one secondary coder. The primary coder put in code for the publication using the Qualtrics survey, which the secondary coder reviewed. If the secondary coder disagreed with the code, the code was changed after a discussion with the primary coder and a third vote. The code included the following sections: Publication, Bibliography, Methodology, Exposure and Population, Outcomes, Quality of study (critical appraisal). Each of these sections consisted of anywhere between 3 to 21 questions. Refer to Appendix III for the detailed survey used to code data from the publications considered in this review.

2.7. Critical appraisal

Each of the 325 publications were critically appraised using a section called ‘Quality of Study’ in Appendix III. We drew on questions used by previous studies [16] to appraise the clarity, replicability and logic of the sampling strategy and analyses, the results obtained and the conclusions and recommendations made in the studies. Additionally, we noted whether a comparator was used in the study or not.

Table 1. A description of each component of PICO to be examined in this literature review.

Component of PICO	Specification
Population	Rural households with land holdings or landless rural households or communities that hold land communally.
Intervention	Trees outside legally classified forests (ToF) that are either planted or exist naturally. E.g. agroforestry, live fences. (Refer to table S1 for the complete list of the ToF practices).
Comparator	a. Household/ local community that is not exposed to ToF systems on an everyday basis b. Household/ local community before it is exposed to ToF systems on an everyday basis
Outcome of interest	Human wellbeing (Refer to figure 1 for a broad overview of outcomes; table S2 for a complete list of outcomes)



3. Results

3.1. Geographic and temporal characteristics

Our literature review was dominated by publications from India ($N = 150$) and Bangladesh ($N = 81$), which account for approximately 71% of our dataset. The map in figure 3(a) shows the geographic distribution of the publications considered in this review. We noted a larger focus on states in Himalayan range in India and Nepal.

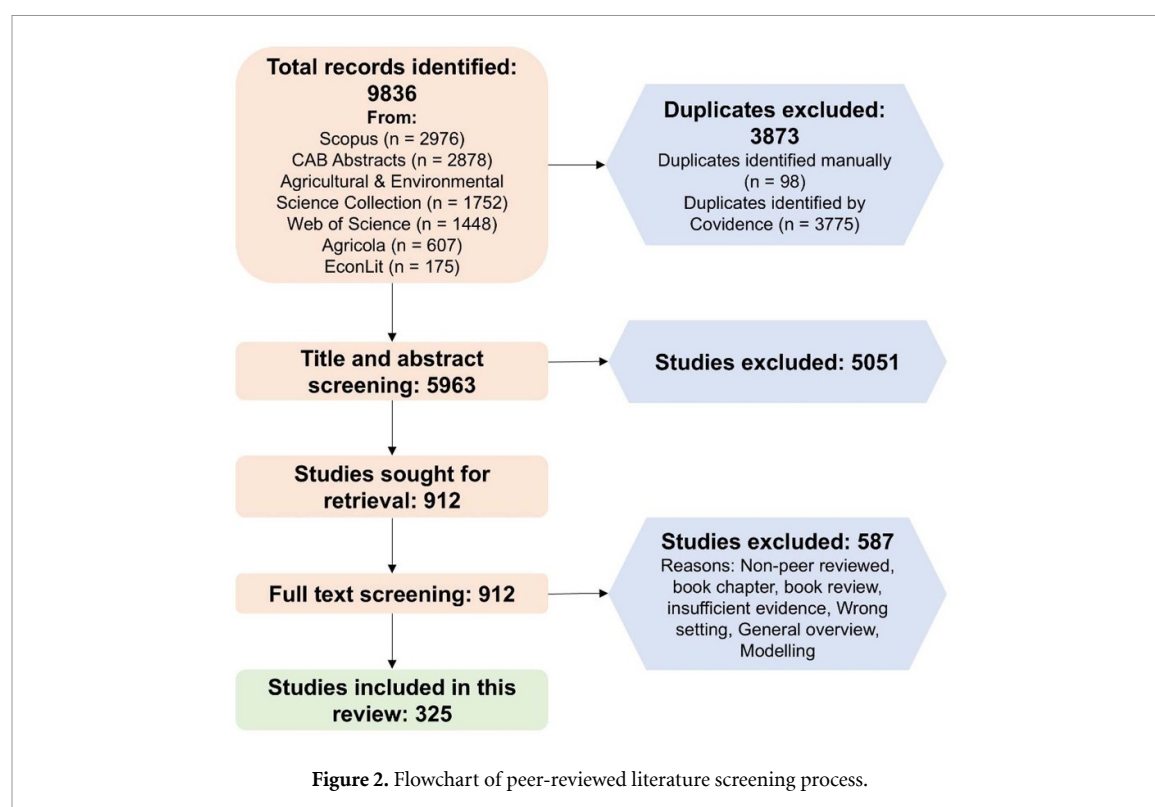
3.2. ToF systems studied in South Asia

We found that tree or forest gardens ($N = 136$ publications) and multipurpose trees on farms ($N = 133$ publications), accounting for approximately 43% of the dataset, were the most popular ToF systems studied in South Asia (figure 4). Additionally, approximately 34% of these ToF systems have a

primary, secondary or tertiary species that is invasive (regardless of its nativeness) in that particular landscape.

3.3. Characteristics of human well-being outcomes studied

Economic security related outcomes (77% of publications; $N = 252$ publications) and material and living standards outcomes (62% of publications; $N = 203$ publications) were the most commonly studied outcomes in South Asia (figures 5(a)–(b)). Economic security related outcomes were most frequently studied in the context of tree or forest gardens and multipurpose trees on farms and lots ($N = 102$ publications each). Material and living standards outcomes were most frequently studied in tree and forest gardens ($N = 95$ publications), followed by multipurpose trees on farms ($N = 91$ publications). We found that material and living standards and



economic security related outcomes were most commonly co-occurring or were the outcomes most commonly studied together ($N = 147$). Health outcomes were most often studied with material and living standards outcomes ($N = 37$) and economic security related outcomes ($N = 36$). There was a significant gap between the most studied outcomes (material and economic security related; $N = 147$) and the remaining co-occurring themes (see table S4 for the co-occurrence of the categories of outcomes in the literature reviewed), further emphasizing the large gap in our understanding of non-material outcomes of ToF systems.

3.4. Changes in human wellbeing associated with ToF systems

The majority of the literature reviewed found an increase in human wellbeing outcomes categories (see figure 6). Economic outcomes—specifically, opportunity for employment and to have a monetary income—were the most reported wellbeing outcomes ($N = 241$ publications). In about 84% of the publications, ToF systems were associated with an increase in economic wellbeing ($N = 202$ of 241 publications). Access to biomass and fuelwood were the outcomes that were most commonly reported on for studies on material outcomes. Approximately 80% ($N = 118$ of 148 publications) and 82% ($N = 112$ of 137 publications) of the studies reported an increase in these two sub categories.

Dietary diversity in the category of health outcomes was most reported, with approximately 83%

($N = 34$ of 41 publications) of the studies reporting an increase in nutritional diversity associated with ToF systems. ToF systems provided opportunities for vocational training such as training in agroforestry practices by governmental and non-governmental organizations ($N = 13$ publications; 100%) and approximately 86% ($N = 18$ of 21 publications) studies reported an increase in access to education, for example for their children through an increase in income associated with ToF systems [34].

The most reported sub category of the agency and social relationships wellbeing outcomes was community interactions, with approximately 81% ($N = 21$ of 26 publications) of the studies reporting an increase in this sub-category. Leisure-related outcomes (for example, access to nature and ability to have a belief system) were the least reported, with studies in half of the sub-categories reporting 100% ($N = 6$ publications each) increase in their wellbeing.

Our review also uncovered some negative outcomes of ToF systems, predominantly in the category of agency and social relationships outcomes. Specifically, the ability to have a political voice had the highest number of studies reporting negative and mixed outcomes ($N = 5$ of 21 publications each), followed by the sub-category of social equity ($N = 6$ of 14 publications). These negative results were more pronounced when we filtered the results to focus on communally held land (figure S1). In this case, the ability to have a political voice was negatively affected ($N = 3$ of 8 publications) or led to mixed outcomes ($N = 3$ of 8 publications) in the literature reviewed. Similarly, in the case of private (specifically, small

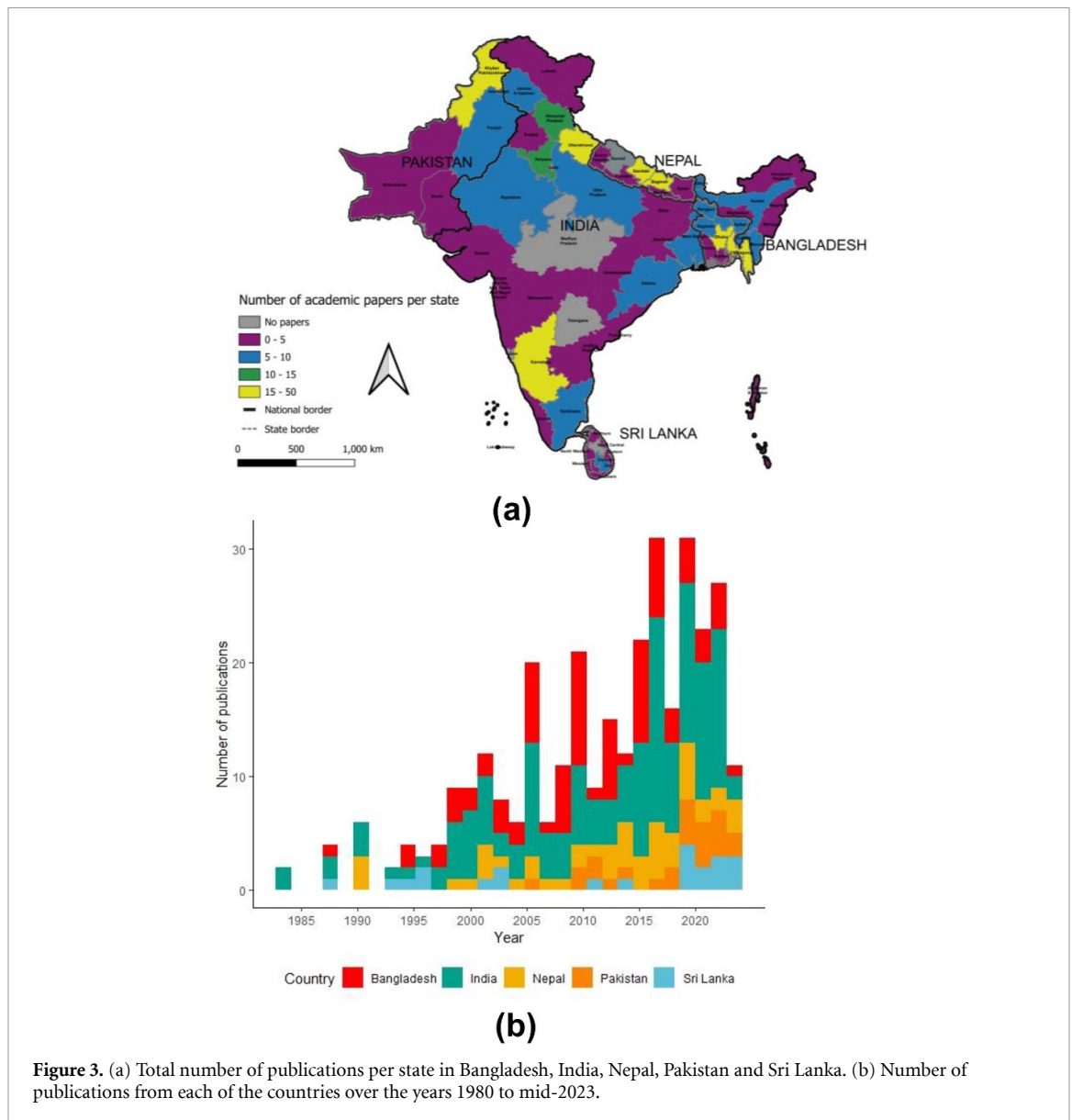


Figure 3. (a) Total number of publications per state in Bangladesh, India, Nepal, Pakistan and Sri Lanka. (b) Number of publications from each of the countries over the years 1980 to mid-2023.

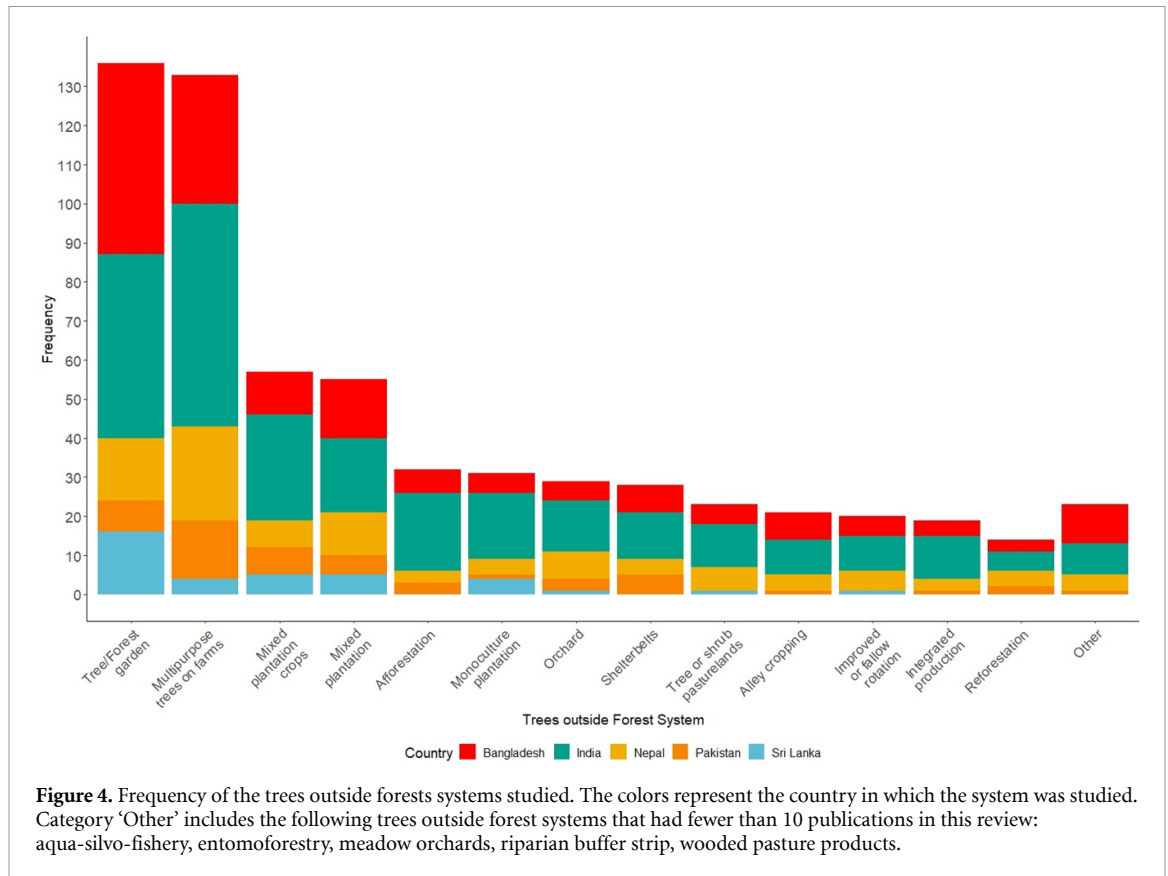
holder farmers) land tenure (figure S2), one's sense of social equity was negatively affected ($N = 2$ of 5 publications) by ToF systems, while the other approximately half of the articles reported mixed outcomes for social equity ($N = 2$ out of 5 publications).

We further examined the ToF systems associated with the different outcomes in each category of human wellbeing outcomes (figures S3(a)–(f)). Most ToF systems and practices were associated with an increase in material outcomes (figure S3(a)). Afforestation and monoculture plantations were associated with reduced access to water (between 20%–50% of the publications reviewed; figure S3(a)). Overall, ToF systems, except monoculture plantations and afforestation had a positive association with educational outcomes (figure S3(b)). 100% of the publications reviewed found that monoculture plantations were associated with a decrease in the respondent's perceptions of their mental health and longevity (figure 3(c)). Most notably, we found that that

afforestation and monoculture plantations were predominantly (between 50%–100% of the publications reviewed) associated with a decrease in agency and social relationships outcomes such as the trust within the community, community interactions, people's sense of social equity (figure S3(e)), and a person's sense of recognition within the community.

4. Discussion

Our systematic review uncovered a large body of research on human wellbeing outcomes of various established ToF systems, including naturally occurring tree populations maintained by local people, tree-based restoration interventions, and tree planting programs in South Asia. We found substantial evidence for beneficial human wellbeing impacts of ToF in South Asia. Not only did ToF supply biomass, diversify diets and incomes, and provide medicinal materials, but they even provided vocational and



educational training opportunities. We also found a limited signal for negative outcomes of ToF systems, such as reforestation and afforestation in particular, in terms of people's sense of social equity and their ability to have a political voice.

Our results are, to a degree, aligned with two other global reviews on the socio-economic outcomes of plantations [16] and ecosystem services of ToF [11]. Similar to these global reviews, we found the largest body of evidence on material and economic outcomes that were predominantly positive. This finding was in line with our expectations given the ease of quantification compared to other wellbeing outcomes such as social equity, education outcomes amongst others. However, our analysis has uncovered results related to other lesser studied human wellbeing outcomes as experienced by populations studied in the publications. For example, by incorporating a vast number of ToF systems we found that certain systems are more susceptible to negative outcomes for people's social relations and sense of agency than other systems. These insightful nuances are key to helping tree planting programs to improve the design and implementation of tree-focused projects in South Asia.

Below, we discuss the following in more detail: (a) the ToF systems we found in this dataset, (b) the

positive and negative wellbeing outcomes and (c) the limitations of our review.

4.1. ToF systems in South Asia

Our review illustrates two possible trends: (a) there is a predominance of certain ToF systems (tree and forest gardens and multipurpose trees on farms) in South Asia as opposed to the broader set of ToF systems such as orchards, entomoforestry and tree and shrub pasturelands or (b) there is a bias in terms of ToF systems that have been studied in this region over the last four decades. Both these possibilities could also be a reflection of policies that promote or implement certain ToF systems more than the others. We interpreted our results as epitomizing a combination of the two. While there is a likely predominance of the two ToF systems [24, 25], the large disproportion points to a potential bias in which systems get studied, over even more economically popular ToF systems such as orchards and mixed plantation crops. Lastly, in light of the UN Decade on Ecosystem Restoration and the push for tree planting-based restoration as potential carbon dioxide removal option for climate mitigation, with benefits for biodiversity conservation, we speculate that some of the ToF systems (for example, commercial crop tree plantations)

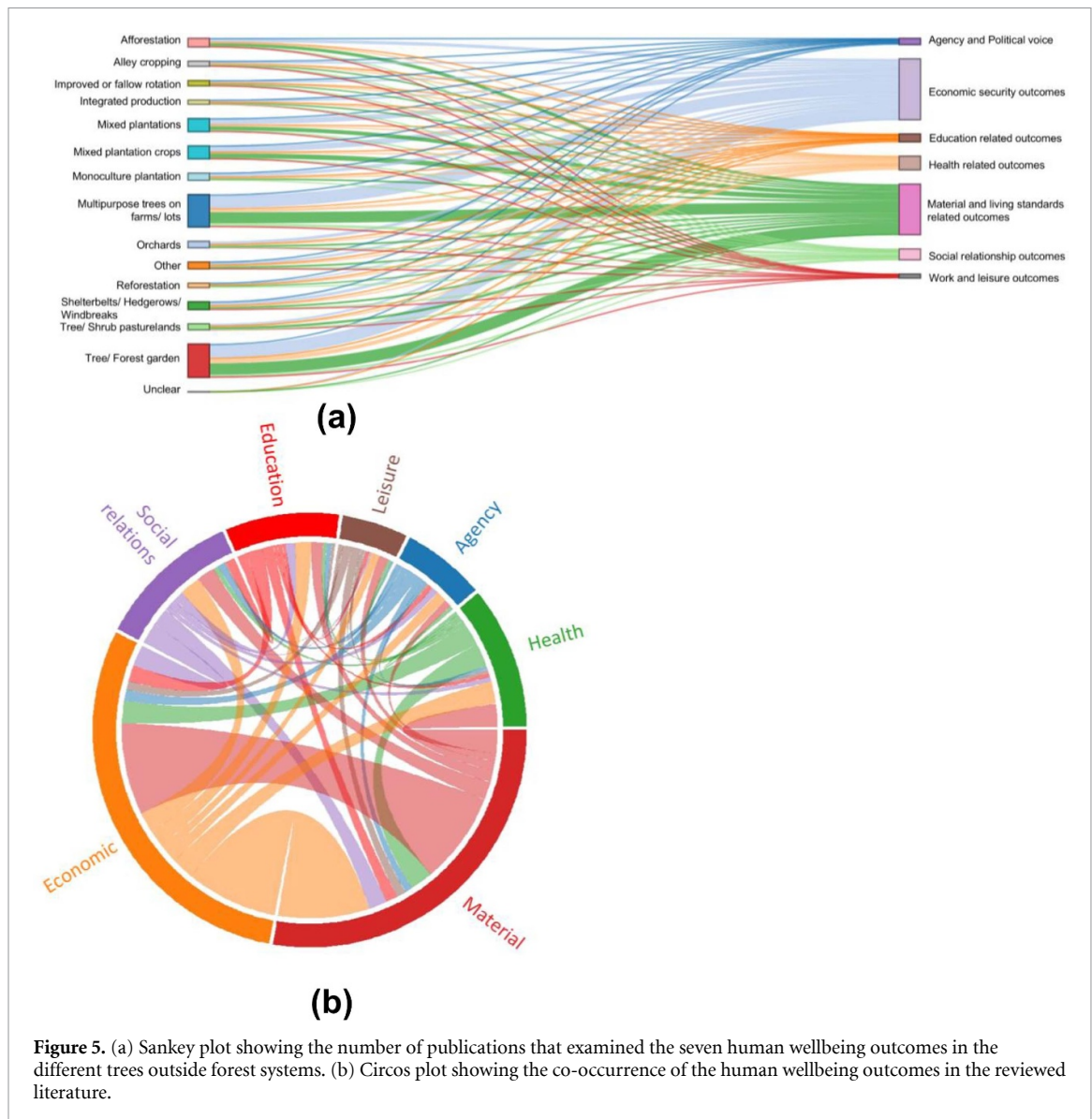


Figure 5. (a) Sankey plot showing the number of publications that examined the seven human wellbeing outcomes in the different trees outside forest systems. (b) Circos plot showing the co-occurrence of the human wellbeing outcomes in the reviewed literature.

we reviewed would not necessarily contribute significantly to these aims or land degradation neutrality, as previous studies have also found [35].

4.2. Closer examination of positive and negative wellbeing outcomes of ToF systems

Our review found a predominantly positive effect of ToF in South Asia. Most cases reported an increased income or opportunity for employment, thereby increasing the respondents' financial wellbeing. For example, by growing trees on common lands in the Terai landscape in Nepal local people were able to increase their income and get access to desirable non-timber products [36]. In Pakistan, the Billion Trees Afforestation Program has generated employment as participants are paid to plant trees across parts of the country [37]. Trees on farms in Bangladesh provide materials such as fodder and fiber in areas with lower forest cover and fewer protected areas [38]. In Sri Lanka and India, commercial tree crops such as rubber and Eucalyptus are significant sources of income

or ways to supplement farming incomes in rural landscapes [39, 40]. However, we posit that tree-based restoration and tree planting projects are often temporary sources of income, and local people's economic security may change following the completion of a project. Similar evidence has been found in Chile, where plantation jobs are temporary, for instance [16]. In another example, the reported economic benefits of tree planting activities in the case of the Great Green Wall in Africa are considered fleeting gains given the temporality of the jobs [41]. In Vietnam, smallholders find tree planting projects to be a quick and temporary source of income due to the short rotation cycles for pulp and woodchip mills, but do not find much social or ecological restoration value in these plantations [35].

We closely examined articles describing negative agency and social relationship outcomes to better understand the kind of projects and circumstances that may have led to these negative perceptions. For example, with the popularization of oil palm

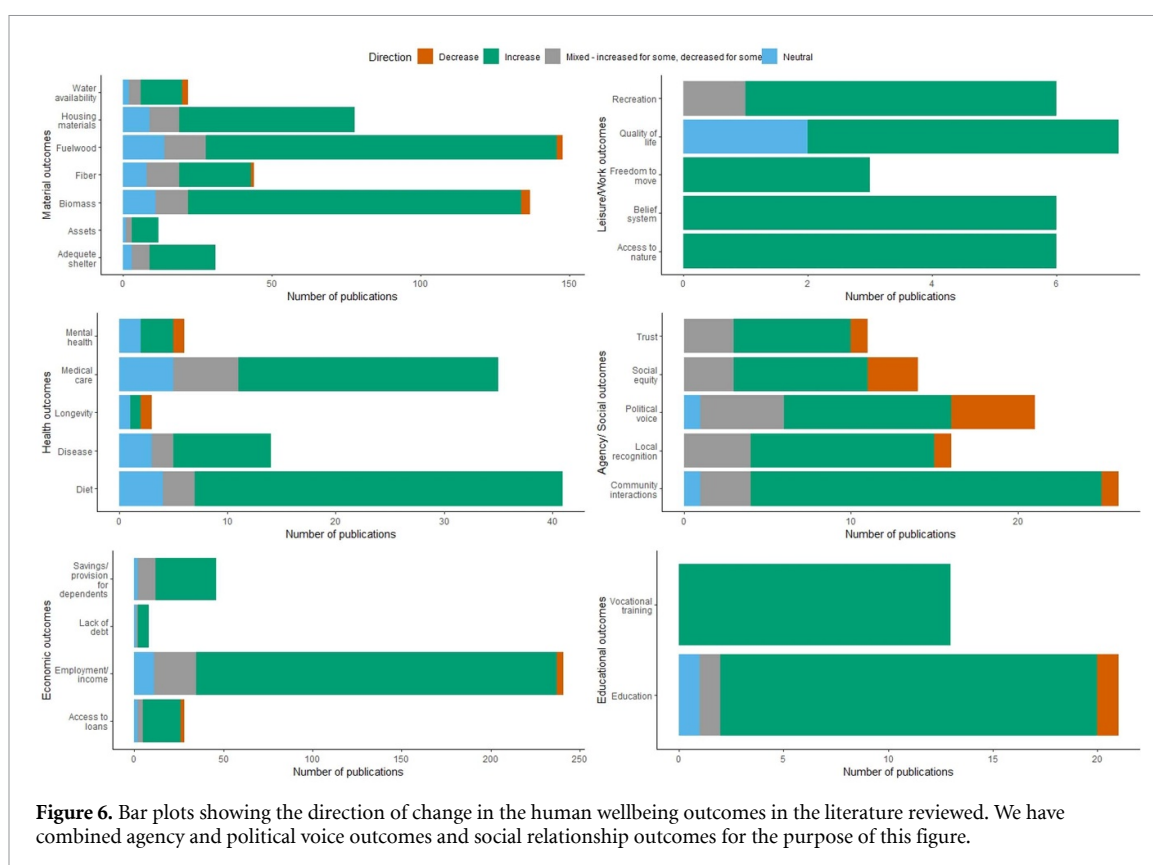


Figure 6. Bar plots showing the direction of change in the human wellbeing outcomes in the literature reviewed. We have combined agency and political voice outcomes and social relationship outcomes for the purpose of this figure.

cultivation, communally held lands fragmented into individual private ownership, mainly belonging to men and not women who normally cultivated lands, and furthered gender and social inequity [42]. Also, local people in Keonjhar, Odisha, felt that the governmental Forest Agency intentionally used the national compensatory afforestation program to grab land and stop them from carrying out their traditional livelihoods on low tree density lands, often referred to as 'wastelands' [43]. In Bangladesh, the government initiated tree plantation drives for a 'social forestry' program in which self-help groups were established and planting materials were distributed by the government and NGOs helping implement the program [44]. However, men in higher socio-economic classes dominated the self-help groups, and the government handed out soil and seedlings of tree species without any understanding of local conditions and inputs from the local people who were meant to plant and use the trees and without any regard to soil salinity [44]. Such design and implementation models can then be improved to avoid creating or reinforcing social inequities and reducing community agency.

In the context of using ToF systems and practices for climate mitigation, practices associated with quick carbon sequestration, such as afforestation and monoculture plantations, could negatively affect people's wellbeing. Although human well-being outcomes are often cast as social 'co-benefits', we argue that they are equally important to consider when

designing tree-based climate mitigation projects, and fostering both human wellbeing and climate benefits should be the goal of NCS using trees.

4.3. Limitations of this review

As with any systematic literature review, the search strategy and access to databases influence the data considered and subsequently the results. Acknowledging this inherent bias in a review, we aimed to widen our search to six databases and thereby diversify the potential data sources to fill the data and evidence gap for South Asia. Although we compiled a large dataset of publications on human-wellbeing of ToF, we acknowledge that our focus on quantitative data and no consideration of qualitative data may have led to the observed dominant focus on material and living standards and economic security outcomes in our data. We only reviewed papers in the English language. Further, we deviated from our protocol [29] in that we only considered peer reviewed literature and were unable to consider gray literature due to the inability to review such a large volume of articles. Thus, we also acknowledge that our language and literature choices prevent us from tapping potentially crucial evidence on ToF published in regional languages in South Asia, most likely available in non peer reviewed journals. Nonetheless, a large proportion of the 325 articles are based on small scale studies carried out locally and published

in relatively lesser known journals globally, highlighting the importance to search widely across multiple databases, as other studies have found [45].

Furthermore, in such systematic reviews, there is a risk of positive publication bias, i.e. positive perceptions of wellbeing outcomes would be more likely to be reported than negative perceptions of these same outcomes.

Also, approximately 15% of the publications considered in this review have some form of implied conflict of interest. An implied conflict of interest, for example, includes publications in which a researcher from a governmental institution is evaluating the financial benefits of a compensatory afforestation project that they have funded. In other cases, an implied conflict of interest is one in which an employee of a company or governmental agency that promotes the use of a particular non-timber product is authoring a paper on the livelihood benefits of the products.

Moreover, approximately 23% of the publications considered for this review did not have clear and replicable data collection and analysis methodologies. Similarly, approximately 28% of this dataset did not have clear justifications for their sampling selection.

Lastly, seven journals (2% of the publications) from this dataset were on the Beall's list of potential predatory journals and publishers [46]. These limitations point to a need for more systematic, robust, and transparent research designs to ease evaluations of which ToF interventions are most likely to be beneficial.

5. Conclusion

Our systematic review synthesizes crucial insights on the human wellbeing outcomes of ToF systems in South Asia. It highlights key aspects of these systems, including the wellbeing outcomes associated with different ToF types, which are crucial for designing and implementing socially and ecologically effective tree planting programs. ToF systems, overall, produce positive multidimensional wellbeing outcomes for local users or local people exposed to these systems.

However, our review also found that ToF from afforestation, monoculture plantations and orchard projects can especially lead to negative or mixed wellbeing outcomes for people, highlighting the need for more thoughtfully designed interventions to achieve both ecological and human wellbeing outcomes.

Our review also throws light on the gaps in our current knowledge, especially related to how ToF systems influence people's quality of life, their access to recreational spaces, or their ability to have and exercise their belief systems, which could be relevant to inform on how to successfully implement tree-based restoration efforts under the contemporary global environmental policy frameworks, including the UN Decade of Ecosystem Restoration.

Data availability statement

Data and code is available on the University of Minnesota Repository at this DOI: <https://doi.org/10.13020/4eyz-fz76> [47].

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Conflict of interest

The authors have no competing interests to declare.

Ethics approval statement

No ethics approval required for this project.

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