



Final report

Project title (German)	Integration von Ernährungs- und Gesundheitsaspekten in Agroforstprojekte der Entwicklungszusammenarbeit in Subsahara-Afrika: eine Machbarkeitsanalyse
Project title (English)	Integrating nutrition and health into agroforestry projects of GIZ and NGOs in sub-Saharan Africa: a feasibility study (Nu-Tree)
Reference number	37998/01
Authors	Dr. Amanda Wendt (wendt@pik-potsdam.de) Dr. Jillian Waid (waid@pik-potsdam.de) Dr. Katja Kehlenbeck (katja.kehlenbeck@pik-potsdam.de) Dr. Giulia Malevolti (giulia.malevolti@pik-potsdam.de) Pauline Harich (pauline.harich@pik-potsdam.de)
Institution	Potsdam Institut für Klimafolgenforschung (PIK) e.V. Telegraphenberg A 31 P.O. Box 60 12 03 D-14412 Potsdam
Project start date	01.04.2022
Duration	26 months
Place	Potsdam
Date	31.08.2024

Contents

1. Project rationale and goal of the project	3
2. Presentation of carried out work steps and applied methods	4
a. Literature review	4
b. Identification of stakeholders	5
c. Workshops conducted	6
3. Results	12
4. Discussion	19
5. Public relations	20
6. Conclusion	21
7. References	22
8. Appendix	22

Summary of the final report

Agroforestry is a sustainable agroecological method combining trees with agricultural crops and livestock. Research has shown its environmental and economic benefits, as well as its role in climate change mitigation and adaptation. However, its nutritional and health benefits are less studied. The Nu-Tree project aimed to explore the existing evidence regarding the link between agroforestry and human nutrition and health, to raise awareness among stakeholders to integrate nutrition and health aspects into future programs and to evaluate impacts.

The project team organized three workshops with stakeholders from various sectors (e.g., research, implementation, civil society, policy-making) and disciplines (e.g., agriculture, forestry, ecology, health, nutrition, economics, social sciences). Participants included German and international organizations, local NGOs, and governmental agencies from sub-Saharan Africa.

The Nu-Tree team conducted a systematic review of peer-reviewed literature on the nutritional and health impacts of agroforestry, completed as a master's thesis, and is currently updating it for a peer-reviewed publication.

For the conceptual framework, the team incorporated gray literature and practitioner perspectives from workshops and interviews. These findings are being used to develop a roadmap for better integrating and evaluating nutrition and health aspects in future agroforestry programs. This roadmap will be shared with stakeholders, outlining steps for integration and identifying beneficial project designs and tools.

Final report

1. Project rationale and goal of the project

Background

Agroforestry is a sustainable agroecological production method that incorporates trees with agricultural crops and/or livestock. Research over the past decades has shown that agroforestry can have many positive environmental and economic impacts, as well as contribute to climate change mitigation and adaptation (Castle et al., 2021; Mbow et al., 2014). Nutrition and health aspects of agroforestry programs, however, are less often researched or included in project plans.

Potential benefits for human nutrition and health range from increased access to nutrient-rich tree foods such as fruits and nuts; increased income through the sale of fresh and processed tree products; increased resilience of farming households through diversification of production and improved overall agricultural production, among others (Rosenstock et al., 2019; Swallow and Ochola, 2006). However, to date, no systematic review is available that specifically focuses on the direct contribution of agroforestry to human nutrition and health. Despite these potential benefits, rigorous empirical evidence is still lacking to put policies into practice, which can be highlighted as a critical research gap.

Goal

The goal of the Nu-Tree project was to study the existing evidence on connections between agroforestry and human nutrition/health and to create awareness of those links with key stakeholders in order to support the implementation of nutrition and health aspects in future programs and the evaluation of their outcomes. The project team carried out its activities in an inter- and transdisciplinary way, cooperating with local, regional, and global stakeholders representing different sectors (e.g., research, program implementers, civil society, and policymakers) and different disciplines (e.g., agriculture, forestry, ecology, health, nutrition, economics, and social sciences). The team especially collaborated and exchanged knowledge with stakeholders based in Germany, as well as with international organizations, and local NGOs and governmental agencies that implemented agroforestry projects in sub-Saharan Africa with a focus on Eastern Africa.

The Nu-Tree project team conducted a systematic review of published results from past and ongoing agroforestry projects with regard to nutrition and health aspects. The systematic review covered scientific literature. For the conceptual framework, gray literature and the perspectives of experts and practitioners were incorporated, using stakeholder workshops and interviews. The findings are being used in the development of a roadmap for better integration and evaluation of nutrition and health aspects in future agroforestry programs. This document will continue to be developed after the project ends. The framework specifically outlined what is needed to better integrate nutrition and health aspects into future agroforestry projects and what project designs and tools could be beneficial for monitoring and evaluation of project impacts.

2. Presentation of carried out work steps and applied methods

The Nu-Tree project started on 1 April 2022. The following activities have been implemented until 31.08.2024:

a. Literature review

The primary objective of the systematic review was to assess the existing evidence on the direct links between agroforestry, nutrition, and health in past and ongoing projects.

To achieve this, scientific literature was examined to find instances where the direct impacts of woody plants in agroforestry systems on human health and/or nutrition were quantified with qualitative or quantitative data.

The predefined direct impacts of woody plants in agroforestry systems were:

- Nutrition (e.g., tree fruits, nuts, vegetables)
- Medicine from trees
- Mental health
- Microclimate (e.g., heat reduction, humidity)
- Air quality
- Infectious diseases

Studies were included in the systematic review if they analyzed, used or collected quantitative or qualitative data **of at least one direct impact of woody plants in agroforestry systems on nutrition or health**. We searched the bibliographic databases PubMed, Scopus, AGRIS and Web of Science from the databases' inception until January 2023. In addition, relevant evidence was identified in reference lists from retrieved articles. We included all articles using original data regardless of study design or geographical region.

We used specific keywords to limit the results to 'agroforestry' land use, which we defined as combining woody plants with agricultural crops and/or livestock on the same land management unit. Keyword combinations included "agriculture" and "woody" or "farm" and "tree*" were used as representative terms for agroforestry and were combined with the predefined direct impact terms or related keywords. The search syntax was slightly adjusted to each database and applied as title and abstract searches.

Duplicate records were detected by the software Rayyan, verified and deleted. Titles and abstracts of the remaining citations were screened independently by two project team members for inclusion and any disagreements resolved by consensus together with a third team member. We obtained the full-text of all relevant papers for final screening.

Since this review focussed on direct impacts of woody plants in agroforestry systems on human health, the included studies had to present original data on the consumption of, for instance, medicinal plant parts of woody plants in agroforestry systems. For nutrition impacts, studies had to refer to consumption of harvested food items from woody plants grown in agroforestry systems or correlate the presence of woody plants with dietary diversity aspects. Authors linking agroforestry and mental health needed to provide empirical data about the perceived impacts of agroforestry on mental health aspects or measures of mental health of people spending time in agroforestry

systems. Studies assessing microclimate and air quality needed to include perceived or actual impacts on the health of agroforestry households or people spending leisure time in agroforestry systems. For infectious diseases, studies had to include measures of disease cases or perceived impacts of the woody plants.

For each of the finally selected studies, we summarized the study characteristics (e.g. year of publication, country, study design, sample size) separately for the direct impact they referred to before we synthesized the data collection methods used and the key outcomes, applying an integrative *a priori* framework of the six selected direct impacts of agroforestry on human health or nutrition. Some studies referred to multiple direct impacts and were therefore analyzed separately for each direct impact.

Due to the high number of scientific publications identified after the initial search, only scientific publications have been included in the systematic review. However, expert knowledge through participatory workshops were additionally incorporated for the development of the conceptual framework.

b. Identification of stakeholders

Project staff contacted the listed organizations, primarily during the first six months of the project. We identified relevant stakeholders using the experience and networks of project team members, combined with the results from an internet search of organizations and institutions engaged in agroforestry research and programs. Relevant stakeholders of these organizations were met in person or online for initial interviews. Additionally, we requested that these contacts provide links to other relevant contact persons in their networks. In total, 33 organizations were present at the workshop in Potsdam (see Table 1).

Table 1: Participating stakeholder organizations in Nu-Tree project workshops

<p>Academic and research institutions</p> <p>Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya Eldoret University, Kenya Laikipia University, Kenya Moi University (MU), Kenya Pwani University (PU), Kenya World Agroforestry Centre (CIFOR-ICRAF), global, headquarter in Kenya Kenya Agricultural and Livestock Research Organization (KALRO), Kenya Kenya Forestry Research Institute (KEFRI), Kenya Kenya Institute of Organic Farming (KIOF), Kenya Makerere University, Uganda Catholic University of Health and Allied Sciences (CUHAS), Tanzania Universität Hannover – Institut für Umweltökonomie und Welthandel (IUW), Germany Munich University (MU), Germany Würzburg University Hospital (UKW), Germany TU Berlin, Germany RWI – Leibniz-Institut für Wirtschaftsforschung, Germany</p> <p>Governmental organizations</p> <p>Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Germany Kenya Forest Service (KFS), Kenya National Museum of Kenya, Kenya</p> <p>Non-governmental organizations</p> <p>Fruity Schools Africa, Kenya Strengthening One Health and Planetary Health in Eastern Africa (SOPHEA), Eastern Africa The Nutrition Alliance for Planetary Health and Budget Transparency (NAPHBUT), Kenya Alliance for Restoration of Forest Landscapes and Ecosystems in Africa (AREECA), several countries in sub-Saharan Africa Vi-Agroforestry, Eastern Africa Greening Africa Together Network, several countries in sub-Saharan Africa Brot für die Welt, Germany Misereor, Germany Welthungerhilfe (WHH), Germany Aktionsgemeinschaft Solidarische Welt, Germany</p> <p>Private sector</p> <p>O'Bao/Elekea Ltd., Kenya Vokenel Enterprises Ltd., Kenya</p> <p>Other organisations</p> <p>Community Tree Nursery Growers Association of Kenya (COTNGAK), Kenya Kenya National Farmers' Federation (KENAFF), Kenya</p>

Further stakeholders such as Fairventures Worldwide, Inkota Netzwerk e.V. and ZALF (all based in Germany), Kenya Organic Agriculture Network (KOAN), the NGO Trees for Kenya (based in Kenya), as well as several universities involved in agroforestry research were identified and contacted. Some of the identified stakeholders could not participate in the workshops, but were interviewed individually.

c. Workshops conducted

Nu-Tree conducted **three workshops** that employed various participatory methods aimed at soliciting feedback, stimulating discussions, and fostering collaboration among participating stakeholders. The selected methods aimed to ensure maximal and comprehensive stakeholder

engagement, encourage diverse perspectives, and build a collaborative network for future agroforestry projects integrating nutrition and health aspects. The activities included:

- **Participant and project team presentations:** Allowed sharing of knowledge and experiences as well as insights from various projects.
- **Small group work and large group discussions:** Facilitated in-depth discussions and cross-interaction among participants. Integration of multiple participatory methods such as small group work and large group discussions ensured comprehensive discussions and cross-interactions among participants.
- **Feedback sessions:** Provided opportunities to refine concepts and frameworks based on participant input.
- **Question and Answer sessions:** To clarify concepts, share knowledge, actively engage, and address doubts, ensure participants understood the presented content thoroughly and foster a deeper exchange of ideas.
- **Social interactions:** Activities like group dinners fostered collaboration, build relationships, and enhance networking among stakeholders

1. Stakeholder workshop at PIK in Potsdam (hybrid)

Purpose: The workshop was designed to gather insights from diverse stakeholders on integrating nutrition and health into agroforestry projects.

Activities:

- **Keynote presentations** of Nu-Tree team members for introducing the project and knowledge transfer
- **Participant presentations:** Each participant shared their organization's projects and experiences.
- **Group work and plenary discussions:** small group discussions and larger plenary sessions facilitated in-depth conversations on integration of nutrition and health aspects in the participants' projects as well as on the experienced challenges and potential solutions.
- **Q&A sessions:** Structured sessions provided opportunities for participants to seek clarification and deepen their understanding of presented topics.
- **Networking opportunities:** Social interactions, including a group dinner, encouraged networking and collaboration among participants.

On 28/29 June 2023, the Stakeholder Workshop was conducted at PIK in Potsdam. A total of 27 participants attended (partly hybrid), including two from GIZ, three from universities in Kenya and Germany, seven from NGOs in Germany and one each from a CG center and a farmer association in Kenya. During the workshop, the Nu-Tree team presented background information on the topic and the project (Figure 1) as well as first results of the systematic literature review, followed by presentations of the participants on their past and on-going projects with agroforestry components. Further sessions of the workshop included group work and plenary discussions on the participants' experiences with integrating nutrition and health aspects into their agroforestry programs, constraints that may hinder such an integration and suggestions for overcoming these barriers in the future. Potentials for developing future joint agroforestry projects that better address nutrition and health aspects were discussed among the participants at the end of the workshop.

A workshop report draft was written and shared with the participants for their additions and comments, which were included in the final report.



Figure 1: Impressions from the first Nu-Tree workshop in Potsdam. From left to right: (1) Dr. Katja Kehlenbeck giving an introductory presentation, (2) group picture of the workshop participants, (3) group exercise on the challenges and solutions of integrating nutrition and health into agroforestry projects

2. Stakeholder workshop in Nairobi, Kenya (hybrid)

Purpose: The workshop was designed to refine the conceptual framework and to develop a roadmap for integrating nutrition and health into agroforestry projects in Eastern Africa.

Activities:

- **Keynote presentations** of Nu-Tree team members for introducing the project and knowledge transfer
- **Participant presentations:** Each participant shared their organization's projects and experiences.
- **Group work:** Participants engaged in focused group discussions on project successes, challenges, and research gaps.
- **Q&A sessions:** Structured Q&A sessions followed each presentation to address queries and enhance understanding.
- **Collaborative session:** Collaborative sessions were conducted to draft a roadmap outlining key strategies and actions.
- **Social interaction:** A buffet dinner provided further networking opportunities and informal discussions.

On 15/16 November 2023, a two-day Stakeholder Workshop on Agroforestry for Nutrition and Health was held by the Nu-Tree team in the Jacaranda Hotel, Woodsvale Close in Nairobi, Kenya. A total of 46 participants attended the workshop, with 29 attending in person (Figure 2) and 17 joining online. The physical attendees included representatives from various organizations: ICRAF, WHH, KENAFF, KIOF, KEFRI, KFS, O'Bao, Vokenel, COTNGAK, Vi-Agroforestry, Pwani University, KALRO, Laikipia University, JKUAT, Makerere University, SOPHEA, NAPHBUT, and Fruity Schools Africa. The online participants included representatives from GIZ, SOPHEA, UKW and CUHAS.

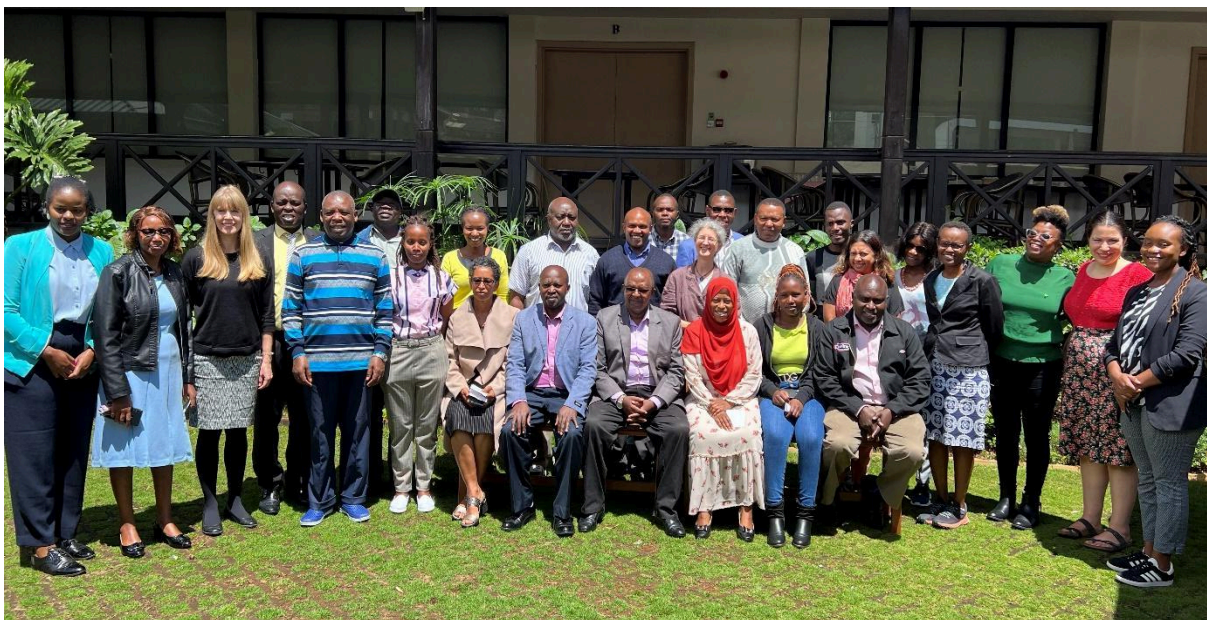


Figure 2: Nu-Tree workshop participants at Jacaranda Hotel in Nairobi, Kenya.

On day 1, the Nu-Tree team outlined the project and its activities and outputs before delivering a presentation on "Agroforestry for Nutrition and Health," emphasizing the ecological and nutritional benefits of trees in agroforestry systems, particularly in Eastern Africa.

Following this, participants shared insights into their respective organization's projects and research initiatives. Julia Knollmann from PIK concluded the session with a presentation on the results of a systematic literature review on agroforestry's direct impacts on nutrition and health. A subsequent question-and-answer session provided further clarity. As a next step, a preliminary draft of the conceptual framework for integrating nutrition and health into agroforestry projects was briefly presented. It detailed how agroforestry adoption can enhance dietary quality, thereby improving physical health and overall well-being. Group work was then conducted where participants shared experiences in agroforestry projects with nutrition and health aspects. Five groups were formed, including an online group, to discuss topics such as successes, challenges, enabling factors, research gaps, and evaluation issues related to their projects. Afterwards, groups presented their findings to the plenum and discussed research gaps.

On day 2, participants critically reviewed the conceptual framework presented the day before and identified missing relationships. Jillian Waid from PIK then introduced project design methods and indicators for monitoring nutrition and health outcomes in agroforestry projects and for evaluating their impact. Participants then jointly developed an outline of a roadmap for better integrating nutrition and health into future agroforestry projects. Finally, the workshop participants brainstormed possible joint proposal ideas for agroforestry and nutrition and health, further exploring potential funding opportunities. The workshop ended with a short summary and outlook, including next steps such as further literature collection, roadmap development and dissemination, and further workshops.

Third workshop (online dissemination event)

Purpose: To disseminate project findings and outputs and to gather final feedback on the developed drafts of the roadmap and conceptual framework.

Activities:

- **Keynote presentations** of Nu-Tree team members on the project outputs
- **Small group work:** Participants discussed the draft stakeholder roadmap and possible improvements in small groups, focusing on specific thematic areas.
- **Feedback and reflection:** Sessions included feedback rounds to refine the roadmap and reflect on the project's achievements.
- **Networking opportunities:** Despite being online, participants engaged in virtual networking during the small group work session to explore potential collaborations.

The final online dissemination workshop on *22 May 2024* featured almost 30 online participants (Figure 3) from various institutions, including the National Museum of Kenya, GIZ, KENAFF, Misereor, Jomo Kenyatta University, RWI, WHH, Eldoret University, SOPHEA, Greening Africa Together, and KALRO Kandara.

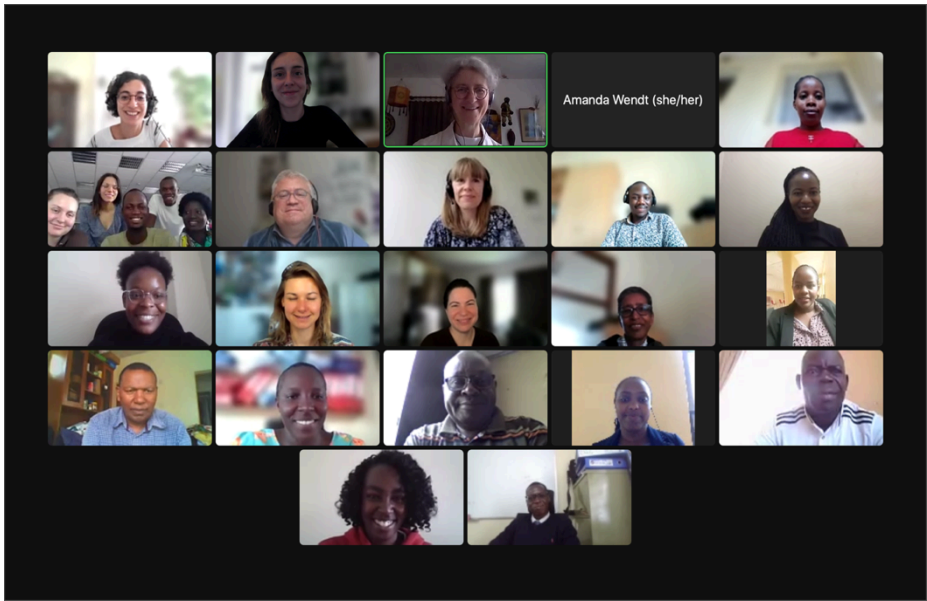


Figure 3: Participants of the final Nu-Tree online workshop (dissemination event).

The workshop started with keynote presentations, including a brief introduction to the Nu-Tree project, results of the systematic review and the adapted "Conceptual Framework Agroforestry' for Nutrition and Health". This framework, first introduced at the previous workshop in Nairobi, was supplemented and adapted based on contributions from the Nairobi workshop participants. The modified conceptual framework was briefly discussed with the participants, incorporating the valuable insights from the attendees. Severine Bogenschütz from PIK then presented the draft structure and content of the stakeholder roadmap which included five key chapters. Participants then engaged in group work to discuss the roadmap content. They had been divided into groups to address the topics of a) project design, methodology, and evaluation, as well as b) stakeholder engagement and collaborative approaches. Each group presented their findings, emphasizing community engagement, capacity building, effective communication, and sustainable project design. The workshop concluded with reflections on the project's achievements and future outlook. Participants were encouraged to maintain the collaborative spirit and share opportunities for future proposals and project development.

3. Results

3.1 Products of the Nu-Tree project

3.1.1 Literature review

The initial literature search resulted in a total of 12,722 articles, of which 5,262 were duplicates and thus removed. The titles and abstracts of the remaining 7,460 articles were screened by two independent reviewers for meeting the inclusion criteria. In this step, 7,402 articles were excluded as they did not meet the criteria. For the remaining 58 articles, a full-text review has been performed, resulting in the exclusion of further 41 papers that did not meet the inclusion criteria. The finally included 17 articles were analyzed in detail to extract and evaluate their main findings. Finally, one further relevant study was obtained from a reference list of an included paper and added, resulting in a **total of 18 studies** providing empirical data on the selected six impact categories for the review (Figure 4).

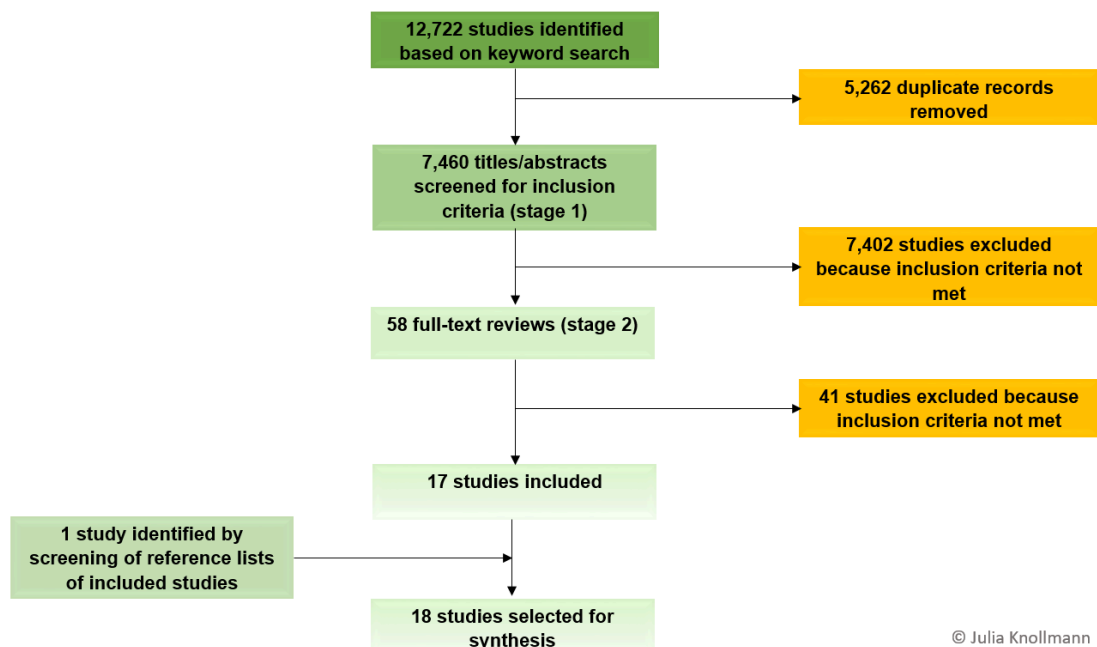


Figure 4: Literature review flow chart for the systematic literature review on the existing evidence of direct impacts of woody plants in agroforestry systems on human health or nutrition.

Most (13) of the included studies referred to the impact on nutrition and used data from african settings (eight studies). Five studies reported empirical data on the direct impact on mental health, two each on microclimate and air quality and one to medicinal use. Some studies covered more than one direct impact. No study was found to examine the direct impact of agroforestry on infectious diseases.

Regarding the direct impact of agroforestry on human nutrition, evidence is given when a study proves the following **five steps**:

- 1) There are woody food plants within the agricultural system.
- 2) The woody plants provide fruits, nuts, edible leaves, or other food products.
- 3) The food products from woody plants are harvested.
- 4) The food products from woody plants are consumed in adequate quantities/frequencies by the household members, including children and women.
- 5) The nutrient contents of food products and/or nutrient intake of study participants/ agroforestry practitioners is documented.

All of the 13 included papers regarding the direct on impact nutrition reported woody plants integrated into the studied agricultural system and therefore fulfill **step 1** of the pathway. The included 13 studies also showed that the woody plants provided food items (**step 2**). However, only four studies provided data on the quantity harvested (**step 3**), referring mostly to fruits and vegetables from woody plants. Regarding **step 4** of the pathway, seven studies documented some data related to consumption of food from woody plants by the studied households, but in four of these studies, the relationship was only documented in an indirect way, e.g. by reporting a generally higher dietary diversity in households managing woody plants on their farms or by assuming a year-round fruit consumption if a number of different fruit tree species with different harvest seasons were cultivated on a farm. **Step 5** of the pathway (i.e. data on nutrients derived from food from woody plants that household members consume) is not assessed in sufficient detail in the 13 included papers. If an adequate nutrient intake is met (step 5), it leads to improved human nutrition and overall health.

For the direct impact of medicinal use, only one study was included in this review reporting medicinal use of moringa by moringa growing households. Many studies were excluded because they did not provide empirical and human-related data regarding consumption frequencies or amounts of woody plant parts with a medicinal purpose, but only lists of such woody plant species.

With regard to the impact on mental health, the five included studies were very heterogeneous in the methods applied or the study populations. They showed some evidence that agroforestry systems have a positive impact on people who work or spend their free time in those landscapes, highlighting particularly aspects of strengthening social relationships, recreation and subjective well-being.

Regarding the direct impact of agroforestry's microclimate on human health, the two included studies provided some qualitative data on the perception of agroforestry farmers. These papers showed that farmers managing agroforestry vegetable gardens perceive more comfort through the tree-influenced microclimate and a lower exposure of agricultural workers to heat and solar radiation.

Only two studies provided some data regarding agroforestry and the direct impact on air quality. The evidence was, however, based only on relatively general statements of a few respondents who said that air quality is a valued ecosystem service in agroforestry landscapes and that trees improve air quality.

In summary, most of the 18 included studies showed a positive impact of woody plants within agroforestry systems on human health or nutrition, however, the evidence is weak and future research is needed. Not a single study could be recommended as a good example for future studies as in each of the included publications important weaknesses were detected. Therefore, **this review**

calls for future well-designed studies to measure the direct impacts of woody plants in agroforestry systems on human health and nutrition. Further assessing this relationship in an empirical approach would provide policymakers and other stakeholders with evidence-based facts to promote health and nutrition through agroforestry.

3.1.2 Workshop reports

Reports of all three performed workshops were developed and disseminated among the participants. Below the key results of each of the workshops are summarized.

1. Key results from the first workshop

- **Systematic review:** The literature review focused on the direct impacts of woody plants in agroforestry systems on human health and nutrition. It highlighted a noticeable gap in research, with most studies emphasizing benefits such as soil fertility and economic impacts rather than direct health outcomes. The presentation detailed the search criteria and databases used, noting the exclusion of studies that did not directly address human health impacts or that focused solely on crops rather than woody plants. Key findings emphasized the need to enhance metrics, such as the Food Accessed Diversity Index (FADI), to better assess nutritional impacts. The discussions also explored broader interrelations, including the role of honey, the impact of land rights on agroforestry, and the effectiveness of extension programs in promoting nutrition education and training.
- **General comments:** Participants valued the workshop a lot and highlighted particularly the knowledge sharing and open-minded discussions as well as the networking opportunity offered by the workshop. All participants were highly interested in joining the upcoming workshop in Kenya for further exchange and networking.

2. Key results from the second workshop in Nairobi, Kenya

- **Systematic review:** Julia Knollmann presented newest findings from a systematic literature review, highlighting the scarcity of robust data on agroforestry's direct impacts on nutrition and health. Out of 7,460 screened titles, only 18 studies met inclusion criteria, with most focusing on nutrition and showing weak evidence across impact pathways. The review underscored the urgent need for more rigorous studies and comprehensive methodologies.
- **First draft of the conceptual framework:** The workshop introduced a conceptual framework designed to integrate nutrition and health aspects into agroforestry projects. This framework demonstrated how adopting agroforestry practices could enhance dietary quality and improve physical and mental health, ultimately contributing to overall human well-being. It emphasized the complexity of this process, highlighting the interconnected nature of various outputs and outcomes. For example, successful implementation required planting fruit trees that would mature, flower, and produce harvests, which then needed to be consumed by families, including children, to achieve nutritional benefits.
- **Critical review of conceptual framework:** During the session, participants engaged in a structured exercise to refine the framework's completeness and coherence. They identified

several key additions and adjustments, including the introduction of new categories such as 'indirect outputs'—for example, increased awareness of agroforestry's links to nutrition and health, job creation, and policy advancements that integrate health aspects. Participants also highlighted 'human well-being' impacts beyond nutrition, including planetary health and improved livelihoods. Moreover, crucial enabling factors for successful agroforestry projects were identified, which had not been included in the original framework. These factors encompassed land availability, tree and land ownership issues, supportive policies, capacity building, and community engagement strategies. Discussions also pointed out challenges related to tree tenure and the need to integrate food consumption links into the framework. Overall, participants affirmed the logical flow of the framework while suggesting that enabling factors could be visually separated in future versions.

- **Stakeholder roadmap development:** Key outcomes included a roadmap designed to educate stakeholders on integrating and evaluating nutrition and health aspects in projects targeting farm households. The roadmap emphasized the importance of integrating nutrition and health, facilitated impact comparisons, and was crafted for a broad audience, including institutions, scientists, and farmers. It covered essential topics such as background information on nutrition and health, critical enabling factors for successful adoption, sound project design methods, appropriate indicator selection, suitable statistical analyses, and stakeholder integration. Participants emphasized the importance of stakeholder understanding and involvement, aiming to connect all project phases toward improving farm household well-being. Plans were made for collaborative review and refinement of the roadmap draft by the Nu-Tree team and participants.

3. Key results from the third workshop (dissemination event):

- **Modified conceptual framework:** The updated "Conceptual Framework Agroforestry for Nutrition and Health" was presented, building on the initial draft from the previous Nairobi workshop. Participants contributed valuable additions, including enabling factors, additional direct outputs (such as environment, inputs, knowledge, and social and political issues), intermediate outputs (primarily environmental), and further outcomes and impacts. These enhancements led to the development of a revised conceptual framework, which was briefly presented and discussed during the workshop.
- **First draft of stakeholder roadmap:** A preliminary draft of the stakeholder roadmap for integrating nutrition and health into agroforestry projects was presented. Organized into chapters, the roadmap aims to educate stakeholders on the importance of these aspects and practical methods for integration. Chapter 1 covers background, objectives, and the scope of nutrition and health in agroforestry. Chapter 2 focuses on the conceptual framework, detailing how agroforestry practices could enhance nutrition and health outcomes. Chapters 3 and 4, discussed in separate breakout sessions during the workshop, addresses project design methods and stakeholder engagement strategies, respectively. Key outcomes from group work included insights into successful practices, such as community tree nurseries, and challenges, including land limitations and cultural beliefs. Enabling factors emphasized the importance of interdisciplinary expertise, effective communication, and optimized land use. The roadmap concludes with recommendations for action and suggestions for further collaboration in agroforestry research and practice.

3.1.3 Conceptual framework and roadmap

A first draft of a conceptual framework of the impact of agroforestry on human well-being was developed by the Nu-Tree team based on findings from the systematic literature review, information from additional scientific papers and discussions with agroforestry experts (Figure 5). This draft was discussed with participants of the second workshop. Overall, participants affirmed the logical flow of the framework design and provided valuable inputs for improvement of the draft. An important request of the participants was to add several ‘enabling factors’ needed as a first step for successful ‘adoption of agroforestry’, which were not originally included in the framework. These factors ranged from land availability and tree property issues to supportive policies, capacity building, and community engagement strategies. During discussions, participants underscored challenges related to tree tenure issues and the need for integrating food consumption links into the framework. Additions were also made regarding further direct outputs (environment and inputs, knowledge, social and political issues), intermediate outputs (environment) and further outcomes. Participants also emphasized ‘human well-being’ impacts beyond nutrition, including planetary health and improved livelihoods.

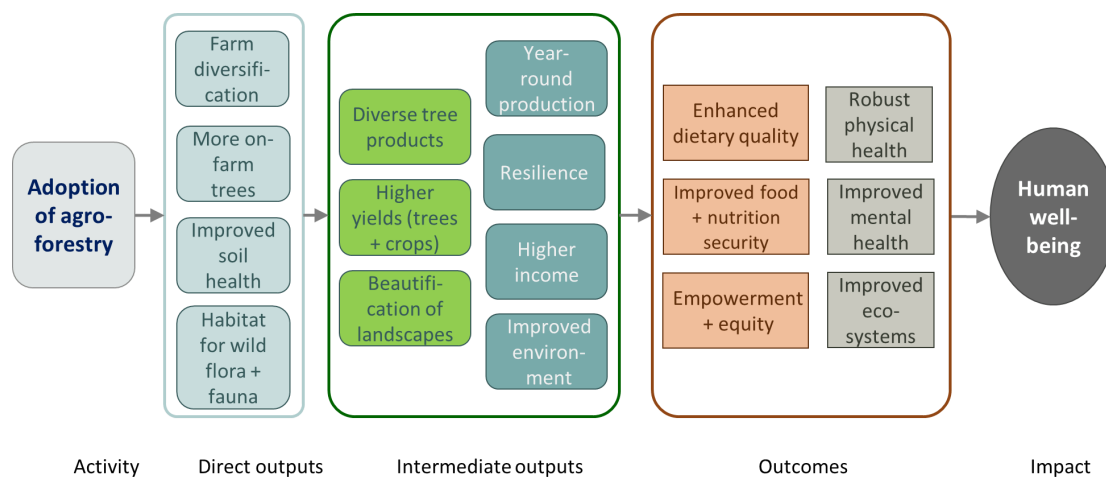


Figure 5: First draft of the conceptual framework

The Nu-Tree team then used the inputs of the workshop participants to develop an improved conceptual framework (Figure 6). This new draft was discussed during the third workshop with the participants. Further changes were not requested and that draft was accepted as the final version of the conceptual framework. This final conceptual framework is the theoretical foundation and was further be used in the roadmap development (see below).

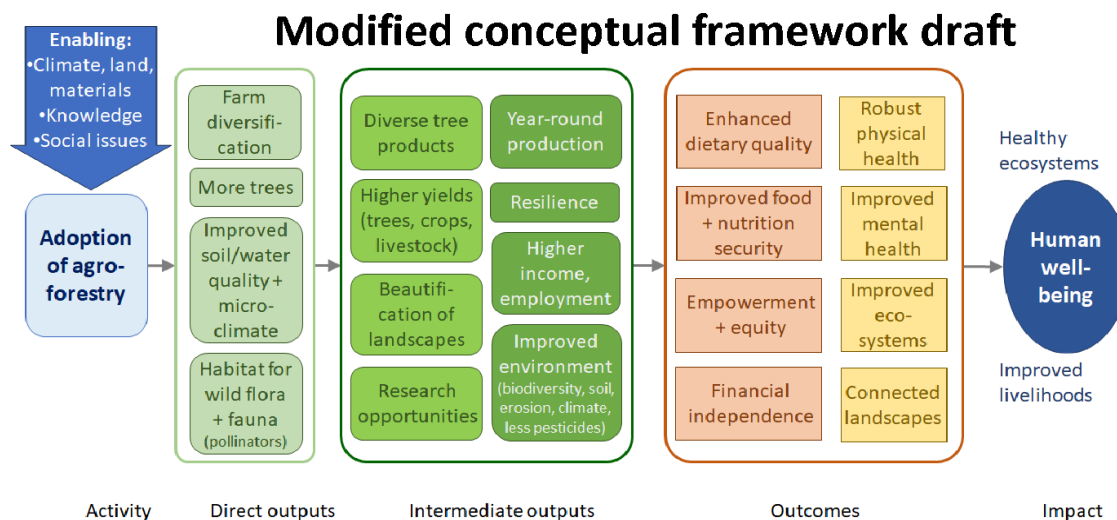


Figure 6: Final conceptual framework jointly developed by the Nu-Tree team and participants of stakeholder workshops.

The **roadmap** aimed at educating stakeholders on integrating and evaluating nutrition and health aspects into their future agroforestry projects, targeting farm households. During the second workshop in Nairobi, a first content list of the roadmap was developed together with the participants. The participants emphasized the need to include short sections on background information regarding benefits from nutrition and health integration and critical enabling factors as well as stakeholder integration. This introduction part should be followed by method parts to support sound project design methods, correct indicator selection and meaningful statistical analyses to enable impact comparisons between different agroforestry projects. It was also highlighted by the participants that this roadmap should be designed for a broad audience including institutions, practitioners, scientists, and farmers.

Based on these results of the workshop, the Nu-Tree team developed a first draft of the roadmap (Figure 7). This was presented at the third workshop and participants discussed the draft during group work, which resulted in an updated improved version of the roadmap's structure along different chapters.

- **Chapter 1** provides background, objectives, and the scope of nutrition and health within agroforestry.
- **Chapter 2** focuses on the conceptual framework, detailing how agroforestry practices can enhance nutrition and health outcomes.
- **Chapters 3 and Chapter 4**, discussed in breakout sessions, cover project design methods and stakeholder engagement strategies, respectively.
- **Chapter 5** recaps key messages and further recommendations for practice.



Figure 7: Draft of the roadmap jointly developed by the Nu-Tree team and workshop participants.

The Nu-Tree team developed the above listed sections further and added text as well as illustrations to the roadmap. The final draft will be shared with all participants for their review.

3.2 Outcomes of the Nu-Tree project

The Nu-Tree project successfully raised the awareness of several key stakeholders in Germany and sub-Saharan Africa regarding the importance of agroforestry for human nutrition and health. Stakeholders from diverse sectors, including farmers, practitioners, NGOs, GIZ as well as research and education, understood the importance of considering nutrition and health aspects in ongoing or planned agroforestry projects. This was mainly promoted by the three workshops and the methodological practices performed in the Nu-Tree project. During these workshops, knowledge and experiences were shared among the participants and the Nu-Tree team and networks were built and strengthened. Activities done during small group works further supported knowledge exchange and networking among participants with different backgrounds.

The involved stakeholders agreed that it is important to monitor and evaluate nutrition and health aspects in their agroforestry projects. There was a lot of positive feedback from the workshop participants regarding the learning effect from the keynotes by Nu-Tree team members on sound research design and indicator selection as well as on statistical analyses. Participants identified knowledge gaps regarding these topics and were very motivated to use the project’s roadmap for improving their future projects. Thus the Nu-Tree project will contribute to better integration of nutrition and health aspects during the implementation of future agroforestry projects of the involved stakeholders.

4. Discussion

The project largely achieved its objectives as expected. In particular, even more stakeholders were reached as planned and this connection enabled effective networking among them, especially during the workshops. This has effectively led to the development of additional by-products of the project, including joint proposal development. Moreover, all workshop participants reported that they highly appreciated the project and its approaches.

However, we recognize three main difficulties. First, some stakeholders could not be reached for active participation in the Nu-Tree project: they either did not react to the invitations or expressed their interest but were then unable to attend, e.g. due to time constraints, travels or already planned other activities. The GIZ was envisioned to be a major partner and some GIZ representatives were among the most motivated and engaged workshop participants, but we were unable to secure active engagement from the GIZ office in Kenya. We also reckon that there was a natural overrepresentation of Eastern African organizations and stakeholders, as Kenya was selected for workshop location, with little representation from other regions of Africa.

Second, we could not include the grey literature (reports, working papers, and other materials) in the literature review. This was caused both by the time constraints linked to the thesis deadlines of the involved MSc student and the low response of NGO partners when asked to provide us with relevant reports.

Third, the roadmap was not fully developed to its final version because a key project member (Kati Krähnert) assigned to the roadmap deliverable was appointed as a full professor at another research institute and therefore left PIK and the project. This had the direct consequence that the team lost her expertise and two indirect consequences: (i) other team members had to take over more tasks; (ii) some tasks were delegated to new temporary staff. This led to a deeper involvement of two student assistants, who had the chance of contributing to the project and significantly helped with the various tasks. By these measures, the project team managed to develop an almost final version of the roadmap.

Regarding the work and collaboration with the different cooperation partners, we acknowledge that the method for identifying stakeholders described above was quite useful and successful. However, the collaboration with some of the identified partners could have been better. We have mentioned the difficulties in, for instance, reaching out to specific GIZ offices and other partners (see above), having some of the identified stakeholders unable to participate because they were too busy to join the workshops, or were not available for interviews. Moreover, we also report some issues linked to Covid-19 which hindered in person interviews and participation of German organization staff at the beginning of the project.

Finally, as the length of the project was limited (even despite its no-cost extension), we did not have time or space to continue with further workshops/exchange events despite the workshop participants' wishes. We also would have liked to follow up with workshop participants who were very much interested in proposal development and contacts to donors, but these topics were not part of the project.

5. Public relations

The primary outputs of the Nu-Tree project consist of the following:

- (1) systematic literature review,
- (2) workshop reports,
- (3) conceptual framework,
- (4) a roadmap.

The systematic review has been published as a master's thesis (Knollmann, 2024) and is currently being updated for submission to a peer-reviewed journal. Preliminary findings from this review were also presented at the Tropentag conference in September 2023 (Knollmann et al., 2023). Additionally, the project's overarching goals were showcased at the Planetary Health Hybrid Annual Meeting in 2022 (Kehlenbeck et al., 2022) and presented to participants of a stakeholder meeting at DBU in Sep 2022 ('Fachtagung Water-Energy-Food Nexus und Planetary Health').

Three workshop reports were created based on sessions held in Potsdam, Germany; Nairobi, Kenya; and online. Each report was reviewed by workshop participants for feedback before the final versions were disseminated.

Preliminary versions of the conceptual framework and roadmap were shared among participating workshop members for their feedback and were extensively discussed as part of group workshop activities. Follow up feedback was also solicited following in-person and online meetings. The finalized conceptual framework and roadmap will be shared among participating workshop participants and more widely among interested members of the agroforestry and health communities.

Each of these four outputs of the Nu-Tree project was presented in preliminary form at the stakeholder workshops and were critically reviewed by participating attendees. Each underwent specific changes to address the recommendations and suggestions given by the workshop participations to better adapt these concepts and messages to the target audience.

In addition to the specified deliverables, several other tangible outcomes have come about due to the workshops and resulting discussions catalyzed by the Nu-Tree project. For example, members of the Nu-Tree project presented work on agroforestry, food security and gender at the 98th Annual Conference 2024 of the Agricultural Economics Society (March 2024) and at the 32nd International Association for Feminist Economics (IAFFE) Annual Conference (July 2024). Several project proposals on the topic of agroforestry in sub-Saharan Africa have been also developed and submitted as a result of the discussions and networking which took place through the stakeholder workshops including an EU Horizon proposal headed by the World Agroforestry Center ICRAF (submitted in Feb 2024; rejected) and three proposals submitted to the REEDA program (Reversing Environmental Degradation in Africa and Asia, UK) with Welthungerhilfe for separate projects in Kenya, Niger and Sierra Leone (submitted in Aug 2023; rejected). In addition, a collaboration with the GATO network (Greening Africa Together) has been established, which resulted in one ASA application (ASA Engagement Global Program, Germany) in Sep 2023 (rejected) and a proposal submitted to BUA (Berlin University Alliance) in May 2024 (under review). Notably, the AfriNutriForest project (concept note submitted to BMEL Germany in Aug 2022, full proposal submitted in Sep 2023) was accepted

for funding and implementation activities, led by Humboldt University in Berlin, began as of 1st April 2024.

List of publications/presentations:

Knollmann J. (2024) What is the existing evidence of direct impacts of woody plants in agroforestry systems on human health or nutrition? A systematic review. Masters Thesis. Eberswalde University for Sustainable Development, Eberswalde, Germany.

Knollmann J., Krähnert K., Wendt A.S., Waid J., Bratschke S., Abigaba D., Kehlenbeck K. (2023) Does agroforestry affect human health and nutrition? Poster presented at the 'Tropentag' Conference, Berlin, Germany.

Kehlenbeck K., Kraehnert K., Waid J.L., Bratschke S., Knollmann, J., Gabrysch S., Wendt A.S. (2022) Integrating human nutrition and health into agroforestry projects in sub-Saharan Africa: a feasibility study. Poster presented at the Planetary Health Hybrid Annual Meeting, Boston, USA. Book of Abstracts, p. 14.

Inspired by Nu-Tree:

Malevolti G., Collins-Sowah P., Maskell G., Abigaba D., Murken L., Waid J., Weituschat C. S. (2024) Agroforestry and household nutrition in southern Madagascar: does gender matter? Working paper presented at the 98th Annual Conference 2024 of the Agricultural Economics Society (AES) (March 2024, Edinburgh) and at the 32nd International Association for Feminist Economics (IAFFE) Annual Conference (July 2024, Rome)

6. Conclusion

The Nu-Tree project has been successful in bringing together a large and diverse group of experts in agroforestry topics and reflect upon the need and the how to integrate nutrition and health aspects in their projects. It has created a network of enthusiastic people from the Global South (particularly Eastern Africa) and the Global North (particularly Germany) willing to collaborate on the topic in future projects. It has generated interest in filling specific research gaps regarding the direct benefits of agroforestry for human nutrition and health and attracted interest from different stakeholders.

However we recognize that within the Nu-Tree project some approaches could have been improved. The first is the lack of funding for Global South stakeholders and potential partners. This could have increased their buy-in and time availability for feedback and active collaboration. Active participation and feedback from the group was only achieved during the times of the workshop, without much spillover post-workshop. This was most likely due to time constraints.

The second difficulty emerged in relation to the time and funding for field activities. We reckon that this would have helped in reaching out better to some more 'elusive' partners.

Third, the final output of the literature review could have perhaps benefited from a broader backing such as including relevant grey literature, however as the review was carried out as a master thesis, limits to its scope and breadth needed to be made.

These difficulties, however, did not substantially change our achieved objectives and deliverables and our overall assessment of the project is positive.

In conclusion, the Nu-Tree project reached its overall objectives and has created promising spillovers to research and project design of agroforestry programs aiming to positively improve nutrition and health.

7. References

Castle SE, Miller DC, Ordonez PJ, Baylis K, Hughes K: The impacts of agroforestry interventions on agricultural productivity, ecosystem services, and human well-being in low- and middle-income countries: A systematic review. *Campbell Systematic Reviews* 2021, 17:e1167.

Mbow C, Smith P, Skole D, Duguma L, Bustamante M: Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. *Current Opinion in Environmental Sustainability* 2014, 6:8-14.

Rosenstock TS, Dawson IK, Aynekulu E, Chomba S, Degrande A, Fornace K, Jamnadass R, Kimaro A, Kindt R, Lamanna C, et al: A Planetary Health Perspective on Agroforestry in Sub-Saharan Africa. *One Earth* 2019, 1:330-344.

Swallow B, Ochola S: Understanding the links between agriculture and health: Agroforestry, nutrition, and health. In *2020 Vision: For food, agriculture, and the environment*. Washington, D.C.: International Food Policy Research Institute (IFPRI); 2006.

8. Appendix

Abstract 1

Knollmann J. (2024) What is the existing evidence of direct impacts of woody plants in agroforestry systems on human health or nutrition? A systematic review. Masters Thesis. Eberswalde University for Sustainable Development, Eberswalde, Germany.

Agroforestry is regarded as a sustainable agroecological production method that contributes to numerous aspects of planetary health. While considerable literature is available on the environmental benefits of agroforestry are well established in the literature, the impact of agroforestry on human health or nutrition is less often researched or included as an explicit objective in agroforestry programs. To assess the extent of this knowledge gap, we conduct a systematic review on the direct impacts of woody plants in agroforestry systems on human health or nutrition, both in qualitative and quantitative studies. We look for the direct impact of agroforestry on human nutrition, medicinal use, mental health, microclimate, air quality, and infectious diseases. Only 18 publications studied empirically the direct impact of woody plants in agroforestry systems on human health or nutrition. We could not find a single study that documented all aspects along the impact pathway towards improved human health or nutrition. Within our search criteria, most of the included studies focus on the impact on nutrition (13) and mental health (5), whereas medicinal use, microclimate, and air quality were less represented (1, 2, and 2, respectively). No empirical study was found on the impact on infectious diseases. Most studies show a positive impact of woody plants within agroforestry systems on human health or nutrition, nevertheless, the evidence is very weak. Among the 18 studies retained, not a single study could be recommended as a good example: in each

of the included publications there are important weaknesses. This review calls for well-designed studies to measure the direct impacts of woody plants in agroforestry systems on human health and nutrition. Assessing this relationship empirically would provide policymakers evidence-based grounds to promote health and nutrition through agroforestry.

Abstract 2

Knollmann J., Krähnert K., Wendt A.S., Waid J., Bratschke S., Abigaba D., Kehlenbeck K. (2023) Does agroforestry affect human health and nutrition? Poster presented at the 'Tropentag' Conference, Berlin, Germany.

Agroforestry - the integration of woody plants into crop or livestock management - is regarded as a sustainable agroecological production method that contributes to numerous aspects of planetary health, including environmental health and human well-being. While considerable literature is available on the benefits of agroforestry on soil fertility, climate change mitigation and the economy of local communities, the impact of agroforestry on human nutrition and health is less often researched or included as an explicit objective in agroforestry programs. Closing this potential knowledge gap on the direct impacts of woody plants in agroforestry systems on human health and nutrition could help to create awareness among stakeholders involved in agroforestry programmes and lead to increased integration of nutrition and health aspects into future agroforestry programs. To assess the extent of the postulated knowledge gap, the present study is reviewing the existing evidence of the links between woody plants in agroforestry systems to human health and nutrition.

In this systematic review, scientific literature is examined in terms of content, whether direct impacts of woody plants in agroforestry systems on human health and nutrition are assessed by qualitative or quantitative methods. Included direct impact categories are human nutrition, medicine from woody plants, infectious diseases, mental health, microclimate and air quality. We searched four bibliographic databases, namely PubMed, AGRIS, Web of Science and Scopus, including all languages and study designs, covering all time periods until January 2023. Experts from different organisations and disciplines will also be interviewed to include information from grey literature such as project reports.

Our search returned 7460 citations of which we included 335 articles after screening titles and abstracts. Most of the included studies refer to the impact categories nutrition and medicine, whereas mental health and air quality are least represented. However, the direct links to human health and dietary intake might be missing in some of these publications. The next steps are full-text review and final selection of papers for data synthesis. This study is still on-going and final results will be presented at the conference.

Abstract 3

Kehlenbeck K., Kraehnert K., Waid J.L., Bratschke S., Knollmann, J., Gabrysch S., Wendt A.S. (2022) Integrating human nutrition and health into agroforestry projects in sub-Saharan Africa: a feasibility study. Poster presented at the Planetary Health Hybrid Annual Meeting, Boston, USA. Book of Abstracts, p. 14.

Agroforestry – combining trees with agricultural crops and/or livestock – is a sustainable agroecological production method that positively contributes to numerous aspects of planetary health, including both environmental health and human well-being. While impacts of agroforestry on the environment and benefits for the economy of local communities are well studied and

documented, nutrition and health aspects of agroforestry programs are less often implemented and researched.

This project aims to generate knowledge relevant for the scientific community and to create awareness among stakeholders that are involved in agroforestry programs in sub-Saharan Africa (SSA) to implement nutrition and health aspects and evaluate these outcomes in future programs. The project addresses the following key research questions: (i) what is the current extent of integration of nutrition and health aspects into past/ongoing agroforestry projects in SSA; (ii) what is needed to better integrate nutrition and health aspects into future agroforestry projects, and (iii) how could implementing organisations/institutions better measure and evaluate the impact of their activities?

Project activities – including key informant interviews and workshops – are carried out in an inter- and transdisciplinary way by cooperating with a variety of local, regional and global stakeholders representing different sectors (e.g. research, practitioners, program implementers, civil society, policymakers) as well as different disciplines (e.g. agriculture, forestry, ecology, health, nutrition, social sciences, economy). As tangible outputs, the projects will generate (i) a systematic review of both the scientific literature and the grey literature on results from past/ongoing agroforestry projects in SSA with regard to nutrition and health aspects, and (ii) a conceptual framework and roadmap for better integration and evaluation of nutrition and health aspects in future agroforestry programs. We expect that the project outputs will sensitize key stakeholders in understanding the importance of integrating and evaluating nutrition and health aspects into their future agroforestry programs.