

RESEARCH ARTICLE

# Gender equity and the sustainability of farming improved vegetable varieties: An analysis of tomato and African eggplant production in southern Mali

Gundula Fischer<sup>1\*</sup>, Martina Cavicchioli<sup>2</sup>, Alpha-Sidy Traore<sup>3</sup>, Jean-Baptiste Tignegre<sup>3</sup>, Kipo Jimah<sup>4</sup>, Simon Wittich<sup>1</sup>, Felix Badolo<sup>5</sup>, Mahamadou Dicko<sup>6</sup>, Chiaka Diallo<sup>7</sup>

**1** International Institute of Tropical Agriculture (IITA), Arusha, Tanzania, **2** International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, **3** World Vegetable Center, Bamako, Mali, **4** International Institute of Tropical Agriculture (IITA), Tamale, Ghana, **5** International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), Bamako, Mali, **6** Association Malienne d'éveil au Développement Durable (AMEDD), Koutiala, Mali, **7** Institut d'économie rurale (IER), Bamako, Mali

☞ These authors contributed equally to this work.

\* [gundulafischer@gmx.net](mailto:gundulafischer@gmx.net)



**OPEN ACCESS**

**Citation:** Fischer G, Cavicchioli M, Traore A-S, Tignegre J-B, Jimah K, Wittich S, et al. (2025) Gender equity and the sustainability of farming improved vegetable varieties: An analysis of tomato and African eggplant production in southern Mali. *PLOS Sustain Transform* 4(10): e0000200. <https://doi.org/10.1371/journal.pstr.0000200>

**Editor:** Rupak Goswami, Ramakrishna Mission Vivekananda Educational and Research Institute, INDIA

**Received:** March 13, 2025

**Accepted:** September 5, 2025

**Published:** October 3, 2025

**Copyright:** © 2025 Fischer et al. This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

**Data availability statement:** Quantitative data that support the findings of this study are publicly available at Harvard Dataverse through the following link: <https://dataverse.harvard.edu/>

## Abstract

Despite its low integration into breeding programs in Africa, vegetable cultivation is increasingly seen as contributing to the achievement of several Sustainable Development Goals, including gender equality and women's empowerment. Seeking evidence of this, we analyze a genetic intensification activity offering improved tomato and African eggplant varieties to women and men farmers in southern Mali. We use a sustainable intensification assessment framework (SIAF), with a mixed methods approach, to conduct a gender analysis of this activity in five sustainability domains. Results and recommendations underline that breeding initiatives need to be accompanied by measures that transform the gender relations in which production is embedded. Equity emerges as a precondition for sustainable vegetable farming.

## Author summary

Crop breeding efforts in Africa have largely focused on staples. Recently, however, vegetable breeding and cultivation have gained more attention and are increasingly seen as contributing to several Sustainable Development Goals, among them gender equality. In this paper, we follow up on a research-for-development activity in southern Mali, in which men and women farmers were offered improved African eggplant and tomato varieties. We use an assessment framework with five sustainability domains for a gender analysis of the activity and the household relations in which vegetable production is embedded. The results underline that vegetable breeding activities will only contribute to gender

<https://doi.org/10.1371/journal.pstr.0000200>

**Funding:** This research was funded by United States Agency for International Development with grant number ARG#: AID-BFS-G-11-00002. It was implemented under the Africa RISING West Africa project, a multi-stakeholder initiative in which all authors collaborated. The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

**Competing interests:** The authors have declared that no competing interests exist.

equality if they are accompanied by measures that transform inequitable gender relations. We offer recommendations for more equitable and sustainable vegetable farming in southern Mali.

## Introduction

Integration of indigenous vegetable crops into breeding programs in Africa has remained relatively low [1,2]. Investments of private and public research funds have focused on staple crops, vegetables often being perceived as supplementary in diets [2,3]. Despite this trend, home gardens have become privileged spaces for participatory development initiatives over the past few decades. They serve as locations for training on improved vegetable varieties and practices, and on health- and nutrition-related benefits [2,4]. Multi-level contributions to the Sustainable Development Goals are assumed, ranging from food security and improved health to income generation, women’s empowerment, and higher resilience of households and landscapes to climate change [5]. However, direct evidence of these outcomes is lacking. This paper provides evidence on the gender outcomes of a vegetable breeding initiative in Mali. It assesses the sustainability and equity of the initiative’s innovations in selected communities. The research focuses on the specific trait preferences of women and men farmers, as well as the gendered conditions that shape vegetable production and use. The following outlines how our study connects to key concepts and approaches related to gender equity in breeding.

## Framing gender equity within breeding initiatives

Genetic intensification is one of three pillars of sustainable agricultural intensification [6]. Sustainable agricultural intensification pursues multiple aims and adds to the achievement of several Sustainable Development Goals [7]. Gender equality and social justice should be among its contributions [8]. Where breeding efforts are gender-blind, they can reinforce existing inequalities or create new ones [9]. Where they take gender differences into account, they can contribute towards achieving equality outcomes and are likely to increase varietal adoption [9–11]. Two general gender approaches can be discerned, that also apply to breeding, namely gender-accommodating (or functional) approaches and gender-transformative approaches [12,13]. The former approach acknowledges gendered constraints and may be effective at meeting immediate challenges. An example would be breeding drought-tolerant varieties for women who do not have sufficient access to irrigation [13]. However, this approach does not address underlying discriminatory norms that disempower women [14,15]. These discriminatory norms produce “disadvantages that prevent women and men, boys and girls from operating on a level playing field” [16]. The process of being fair is defined as gender equity with equality as an outcome [16]. Gender inequities (often expressed in norms) relate to differential access to resources and imbalanced power relations. Gender-transformative approaches aim to shift inequitable norms and promote greater equity [17]. In breeding initiatives,

including those for vegetables, this requires action on two levels. First, it involves a nuanced understanding of the socio-economic characteristics of crop users and their needs in relation to specific varieties [13]. It also requires considering the power dynamics that shape varietal preferences in different contexts [18]. Second, it calls for collaboration with actors who can address inequities beyond the scope of breeding research—such as through complementary agricultural technologies, partnerships with cooperatives, or more inclusive seed delivery systems [13,18–20]. Gender evaluations of vegetable breeding and its outcomes for learning and advancing equity in future initiatives remain limited. This paper addresses this gap using a gender-transformative lens and a sustainable intensification framework that supports a holistic analysis across five domains. The following section introduces this framework.

### Weaving gender equity into a sustainability assessment

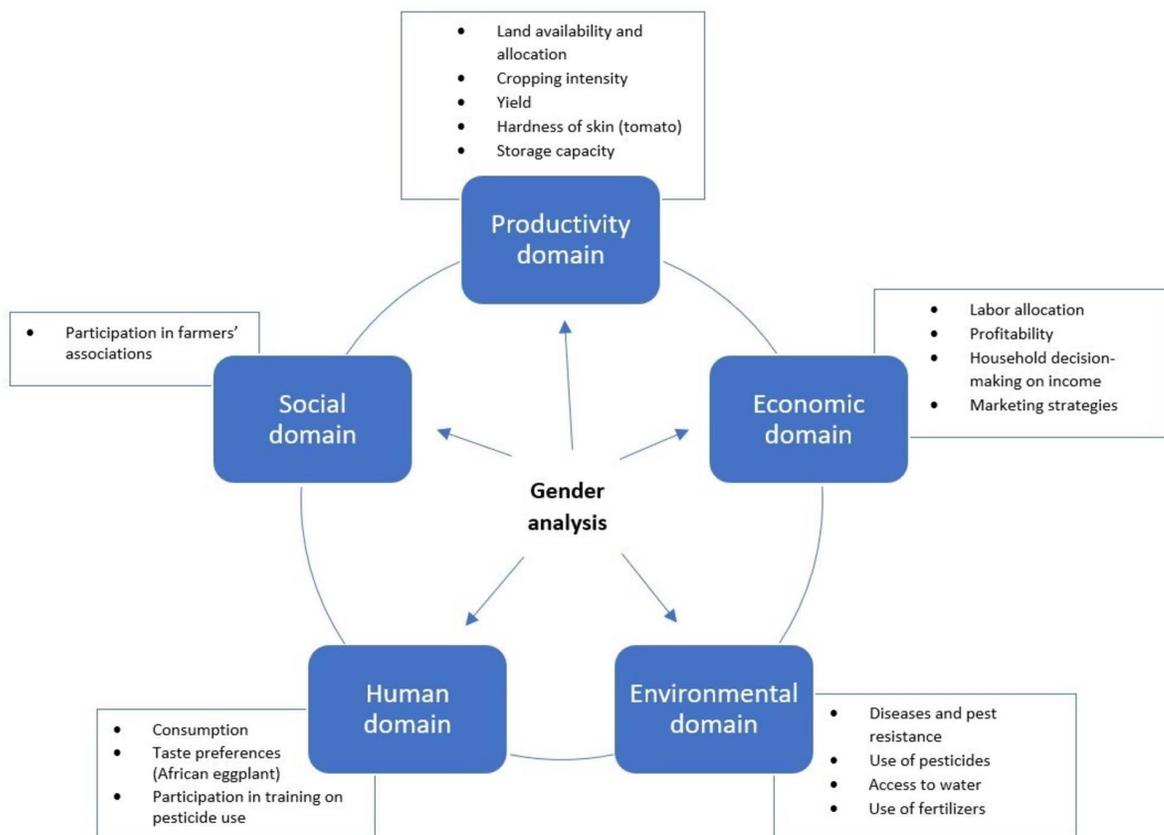
This study analyzes a research-for-development activity in southern Mali under the umbrella of Africa RISING (Africa Research in Sustainable Intensification for the Next Generation) West Africa, a sustainable intensification project with a participatory action research approach. Men and women farmers taking part in the activity tried out innovation bundles comprising improved tomato and African eggplant varieties, pesticides, and fertilizers. They also participated in exchange visits and training on good agricultural practices. This paper explores how sustainable and equitable these innovations were in the selected Malian communities. It does so by investigating (a) men and women farmers' specific trait preferences, and (b) the equitable or inequitable conditions that characterize the production and uses of these vegetables. Third (c), we examine potential linkages between gendered trait preferences and these conditions. Following a gender-transformative approach, the recommendations offered in this paper focus on how to combine varietal improvement with other innovations that can turn production relations more equitable.

For the evaluation, we employed the sustainable intensification assessment framework (SIAF) [21] co-developed by Michigan State University, University of Florida, USAID, and Africa RISING. It became mandatory for Africa RISING evaluations in 2018. The framework consists of five sustainability domains (productivity, profitability, environmental, human, and social) each with suggested indicators. The multiple domains allow for a holistic investigation of innovations farmers have gained experience with at the pre-adoption state. Hammond et al. [22] praise SIAF for its flexibility: researchers can select indicators depending on topic and context and employ various data collection strategies. The framework has been used with a narrower focus on one set of specific innovations, for instance on groundnut varieties in Ghana [23] or forage choppers in Tanzania [24] and with a broader perspective, for instance on combinations of various innovations in Ethiopia [22] or integrated soil fertility management in Tanzania [25]. The original SIAF assigns gender analysis to only one of the five sustainability domains, namely the social domain. The authors outline that gender equity should be assessed through differences in men and women's access to resources, decision-making power, time allocation, and market participation among others [21]. However, the limitation of equity to the social domain may stop scientists from conducting gender analysis in relation to indicators contained in other domains. An example would be the productivity domain in which gendered productivity gaps could be established. Previous Africa RISING gender research [24,26] has therefore suggested that equity issues need to be woven into all five domains to live up to SIAF's interdisciplinary and holistic aspirations. An integrated approach has been showcased for forage choppers in Tanzania [24] and maize leaf stripping in Ghana [26]. For the vegetable breeding study presented in this paper we conducted gender analysis in all five domains and selected a participatory mixed-methods approach. Fig 1 shows the identified indicators for each domain. During data analysis, the indicators allowed us to examine gendered trait preferences, inequities in production, and links between both.

## Methodology

### Context of the study

This study consisted of two phases: first, farmers' experimentation during the 2017/2018 and 2018/2019 dry seasons; and second, a gender assessment, the results of which are presented in this paper. Apart from ensuring women's participation



**Fig 1. Five SIAF domains and gender equity indicators identified for this study.**

<https://doi.org/10.1371/journal.pstr.0000200.g001>

in experimentation, no specific gender measures were taken in the first phase. The gender assessment (decided upon at a stage where experimentation was already ongoing) was part of Africa RISING's participatory action research approach and was meant to provide lessons for future improvements. The study involved nine communities distributed across the Koutiala and Bougouni administrative zones of the Sikasso region in southern Mali. Bougouni, in the Sudan Savanna zone, has more frequent annual rainfall (1081 mm/year) than Koutiala in the Sahelian zone (889 mm/year), which is characterized by more erratic rains and severe environmental conditions. Several ethnic groups reside in the districts, among them Minianka, Senoufo, and Bamana, with the Bamana language serving as lingua franca.

Household land allocation for farming builds on the distinction between household fields, often jointly cultivated for food production under control of the man head; and individual fields as the production units of individual household members [27–30]. Heads typically allocate individual fields to their wives and adult sons, but not to their unmarried daughters. While daughters may be required to contribute labor across various fields, they are more often tasked with domestic responsibilities and have only a limited role in agricultural activities until marriage [28,30]. Consequently, they are not prominently represented in this study.

For the individual fields, depending on the needs and obligations of the field manager, the harvest can be designated for consumption, personal income generation, or both [31]. Larger fields are generally farmed under rainfed conditions, but vegetables can also be cultivated during the dry season if irrigation is possible. Cropping decisions are usually taken by the plot manager. Varietal choices may depend on a range of factors, for instance exposure to the technology or the

capacity to afford inputs. As research on sorghum varieties shows, other household members can influence seed choices [32,33].

In the context of the study, vegetable fields are known as *nako*, a combination of two Bamana terms *na* (sauce) and *ko* (stream), designating irrigated (or lowland) spaces for the production of sauce ingredients [27,34]. These terms reflect gender norms: Bamana men heads are in charge of staple cultivation on household fields, and women farm “sauce-crops” on individual plots [27]. Vegetables are also grown in so-called community gardens, often held by farmers’ associations, where members are allocated one or several plots for individual or collective vegetable production and sales. At times, community gardens are equipped with boreholes for irrigation. Overall, vegetable production in West Africa has been described as an arena for gender negotiations on production and marketing. Economic crises, climate change and horticultural development initiatives have not only intensified women’s garden activities but also attracted men’s competition. Opportunities in vegetable production are shaped by gender relations [27,34–38]. Experimentation with innovation bundles containing improved vegetable varieties is therefore a topic especially suited for gender analysis.

### Study design

**Phase one: Farmers’ experimentation.** In 2017, the World Vegetable Center Mali (under the USAID-funded Africa RISING West Africa project) prepared innovation bundles comprising seeds of improved tomato and eggplant varieties, along with mineral fertilizer, biopesticides, and good agricultural practices, for participatory on-farm experimentation and evaluation. The activity aimed to promote knowledge exchange among farmers, and between farmers and scientists. Further dissemination of varieties that had already been released was also needed. For farmers’ comparison, breeders selected three varieties of each vegetable, some of which had been introduced to the national catalogue of improved vegetable varieties by World Vegetable Center Mali and Mali’s Institute of Rural Economy. Other varieties were known from the local seed market. One local variety for each vegetable species served as a control. Local varieties not originating from breeding programs were among the most farmed in the study sites. Breeders’ selection criteria for the varieties to be introduced in the experiment included: yield performance, nutritional intake, fruit size, taste, and storage life. Table 1 shows the names used in the Malian catalogue of vegetable varieties, in the market, and locally.

African eggplant (*Solanum aethiopicum* [L.]) and tomato (*Solanum lycopersicum* L.) are among the most farmed vegetable crops in Mali [27]. While African eggplant is considered a cultivar specific to certain areas of Sub-Saharan Africa, tomato is consumed globally [2]. The decision to focus on African eggplant and tomato for experimentation was guided by the fact that both vegetables are popular among small-scale farmers for income generation and household consumption.

**Table 1. Selected varieties (names used in the participatory evaluation in bold).**

Vegetable species	Local name	Other names
Tomato	<b>Kénéya</b>	AVTO0102
	<b>Kologuelen</b>	Rio Grande
	<b>Bèbi yèrèyé</b>	AVTO0103
	<b>Yerekasi</b>	Local variety
African eggplant	<i>N’gôyô djèma</i>	<b>Neguetan</b>
	<i>N’gôyô missèni</i>	<b>Keur-bindaw</b>
	<i>N’gôyô timiman</i>	<b>L10</b>
	<b>Yerekasi</b>	Local variety

Note to Table 1: *Kénéya*, *Bèbi yèrèyé* and *L10* were all released in the 2012 Malian catalogue of vegetable varieties. World Vegetable Center was not involved in certification of *Kologuelen*, *Keur-bindaw* and *Neguetan*, which are known as commercial varieties in Mali.

<https://doi.org/10.1371/journal.pstr.0000200.t001>

Mali's national production of the two vegetables has sharply risen over the past years from 15,525 tons of eggplant in 2010–99,841 tons in 2020 and from 41,293 tons of tomato in 2010–233,705 tons in 2020 [39–41].

For field demonstrations, two fenced technology parks, each measuring approximately 2 hectares, were set up in N'Golonianasso and Madina, two of the nine selected communities in Sikasso region. They were equipped with a borehole with solar pump and a drip irrigation system, respectively. Field technicians managed the parks and used them for training, to which farmers from the neighboring communities were invited. At an inception meeting (which was attended by farmers, local chiefs, and extension agents) eligibility criteria for participation in experimentation were laid open: participants had to live in one of the nine selected communities and had to have a plot with adequate irrigation. A total of 121 farmers (82 women and 39 men) engaged in training and subsequently experimented on individual plots inside and outside community gardens. Farmers tested three improved varieties and one local variety of the two selected species. At the end of the experiments, field technicians collected yield data on the two technology parks of N'golonianasso and Madina, and on the fields of 75 farmers (56 women and 19 men) out of the original sample, who had maintained interest in collaborating with the field technicians. In the years preceding this activity, Africa RISING had initiated a collaboration with the farmers' associations in Koutiala and Bougouni regions, to which many of the involved men and women belonged. Yield data (productivity domain) from both technology parks and farmers' fields are included in the results presented in this paper.

**Phase two: Gendered sustainable intensification assessment.** Following the on-farm experimentation, a team of social and biophysical scientists, field technicians, and research assistants explored farmers' experiences with the innovation bundles. Most team members had been involved in vegetable research and development in Mali before. Some had led previous activities related to farmers' experimentation. The methodology to assess the bundles was designed based on the SIAF [21] with the modification that gender issues need to be assessed across all five domains. Part of research planning was therefore to identify questions relevant for gender analysis in each domain. This process took place during a two-day stakeholder workshop in February 2019. Following the SIAF-proposed approach for objective-oriented indicator selection [21], we invited an interdisciplinary group of scientists, research assistants, and field technicians and introduced them to the assessment framework, including its domains and indicators. Participants proposed and discussed indicators based on two criteria: 1. Relevance to the objective of conducting a gendered sustainability assessment of the innovation bundles, and 2. Feasibility, considering the team's expertise, available funding, and time constraints. For the first criterion, the final selection was informed by participants' observations during farmers' experimentation (phase one), as well as by gender-related insights from other studies conducted in similar contexts in Mali. The two most important steps in the indicator selection process are outlined in more detail below.

In a first step, participants familiarized themselves with the indicators in each SIAF domain. The productivity domain captures cropping and livestock productivity, post-harvest losses, and cropping intensity (to mention the main indicators). Profitability, labor, market participation, and market orientation are among the indicators in the economic domain. The environmental domain focuses on natural resources needed for agriculture (soil, water etc.) and pollution resulting from agricultural activities (pesticides, greenhouse gas emissions etc.). Nutrition, food security and the capacity to learn and adapt can be found in the human domain. Finally, the social domain deals with equitable gender relations, collective action, and the ability to resolve agricultural or resource management conflicts. More detailed information on domains and their indicators is contained in Musumba et al. [21].

In a second step, the team limited indicators to those relevant and feasible for the assessment of tomato and African eggplant varieties in the research communities. A gender perspective was woven into each domain. For instance, the productivity domain was amended to include questions on how gendered household land allocation interacts with cropping intensity. This refers to the number of times a man or a woman farmer can cultivate a crop on the same plot in a year. A second example relates to the environmental domain: questions were established to reveal men and women farmers' access to water for vegetable irrigation and their coping strategies in the face of shortages. Indicators for the five domains were then allocated to the different evaluation tools. Fig 1 provides an overview of the aspects raised in each SIAF domain through the mixed-methods approach.

The evaluation consisted of a survey and focus group discussions (FGDs) with the same respondents. The survey was administered to individual respondents (in a private space) before commencement of focus group discussions. A participatory matrix scoring tool, developed from the Participatory Action and Learning approach [42] and SIAF [21], was embedded in FGDs based on Fischer et al. [43]. In terms of information gathering, the survey captured demographic and other information, such as challenges in access to resources (land, water, and farm inputs) and post-harvest management, as well as intra-household decision-making and labor allocation in vegetable production. The matrix scoring tool promoted discussions on selected varieties and gender aspects in each sustainability domain. During the matrix scoring exercise, participants compared the varieties they had experimented with (improved and local) and scored them against criteria associated with four of the five SIAF domains: yield (productivity domain); profitability (economic domain); resistance to diseases and pests (environmental domain); and home consumption (human domain). For tomato varieties, skin hardness was added as an evaluation criterion to the productivity domain, while taste represented an additional criterion for egg-plant under the human domain. Scoring of each criterion was followed by discussions on farmers' individual experiences with each variety. Also, men and women were prompted to analyze the overall results of their matrix scoring exercise. Other criteria in the four domains and those in the social domain (see Fig 1) were covered by questions in the survey and FGDs. All in all, the research team conducted 12 gender-separate FGDs with participants from all nine communities. Recordings from FGDs were transcribed and translated from Bamana to French and analyzed manually using qualitative content analysis. Results from matrix scoring exercises were collated and used to indicate tendencies. The study received ethical clearance from the Internal Review Board of the International Institute of Tropical Agriculture and followed Africa RISING's engagement standards for participatory research (<https://hdl.handle.net/10568/34830>). An oral informed consent procedure, deemed adequate due to the low literacy rates in the research context, was approved and implemented before the focus group discussions were conducted or questionnaires administered. Oral informed consent was obtained from all study participants.

**Sampling and sample description.** For this second phase of the study, the initial experimentation sample of 121 farmers was reduced to 75 farmers (56 women and 19 men). This sample was considered feasible given the limitations in time and funding. In both phase one (experimentation) and phase two (gender assessment), the sampling process was purposive, with farmers engaging on a voluntary basis. Despite efforts to achieve a gender-balanced sample, more women than men took part in experimentation and evaluation. Off-season vegetable production is dominated by women in the study site. Results are in a strict sense non-representative, and descriptive statistics must be read with care. Comparisons between men and women in the analysis need validation through follow-up investigations with a larger sample including more men.

Survey data show diversity in terms of respondents and household arrangements. The sample comprised married men and women (who identified as man heads and wives of the head), widows, and adult sons. The latter group included married men who lived in the compound headed by their father. Respondents belonged to polygamous households (73.33%) and monogamous households headed by men (MHHs) (18.67%). There was also a smaller number of woman-headed households (WHHs) (8%). Some widows in the study context controlled most of the farming production including economic decisions formerly taken by their husband, while others identified themselves as "wife of household head" since they had been formally entrusted to a second husband. Among married women in man-headed polygamous households, 21 indicated they were the first wife, and 18 the second wife. Only one woman ranked herself as fourth wife. This is in line with national statistics presenting socioeconomic characteristics of domestic units in the Sikasso region, which record a higher incidence of polygamous households with two wives. Women living in polygamous households with one other wife made up 40.2% of the sample as against 5.6% of women having two or more co-wives [44]. Intersectional aspects were considered in the analysis to the extent possible. However, the small sample size required caution and limited the depth of insights that could be drawn. Table 2 captures demographic information on the sample for this evaluation.

**Table 2. Demographic information on respondents by gender and household type.**

Gender and household type	Average age (years)	Number of participants						District	
		Marital status		Education				Bougouni	Koutiala
		Married	Widowed	Primary	Secondary	College	No formal education		
Women in man-headed households N=50	43.3	44	6	4	2	6	38	28	22
Men in man-headed households N=19	41.5	19	0	3	0	0	16	6	13
Women in woman-headed households N=6	57.3	0	6	0	0	0	6	4	2
Total N=75	47.3	63	12	7	2	6	60	38	37

<https://doi.org/10.1371/journal.pstr.0000200.t002>

Although all men and 82.14% of the women respondents had cultivated both vegetable crops prior to the research activity, half of them had never farmed improved varieties of tomato or African eggplant. Men were more likely than women to have had experience with improved varieties of tomato (73.68% men versus 41.07% women) and eggplant (57.89% men versus 35.71% women). Six out of seven adult sons in the sample were well acquainted with improved tomato varieties, possibly suggesting age differences. More than one third of the participants (34%) were familiar with some of the varieties introduced through the innovation bundles. In the survey, respondents saw high prices as the most important reason for not buying seeds of improved tomato and eggplant varieties, followed by low availability of the seeds in the market, preference for the local variety, lack of knowledge about improved varieties, and low experience in vegetable farming.

## Results

Men and women farmers' varietal preferences (Tables 3 and 4), together with findings from the FGDs and the survey, underlie the following gender analysis. The presentation follows the five SIAF domains and selected aspects within each domain (Fig 1).

### Productivity domain

**Land availability and allocation.** Man-headed polygamous households in the sample had on average more farmland (17.2 ha) and more members (27.1) than other household types (WHH: 12 ha and 18.3 members; MHH monogamous:

**Table 3. Men and women farmers' evaluation of tomato varieties based on matrix scoring (highest score bold).**

Evaluation criteria (SIAF domains)	Gender	Tomato variety				Total (%)
		Kénéya (%)	Kologuelen (%)	Bèbi yèrèyè (%)	Yerekasi (local variety) (%)	
Yield	Men	26.00	<b>32.00</b>	28.00	14.00	100
	Women	25.49	<b>37.25</b>	27.45	9.80	100
Profitability	Men	19.14	<b>46.80</b>	19.14	14.89	100
	Women	28.57	<b>44.89</b>	18.36	8.16	100
Pest and disease resistance	Men	25.00	20.45	<b>36.36</b>	18.18	100
	Women	<b>31.25</b>	29.16	<b>31.25</b>	8.33	100
Consumption	Men	15.21	<b>39.13</b>	21.73	23.91	100
	Women	25.00	<b>39.58</b>	25.00	10.41	100
Hardness of skin	Men	21.27	<b>40.42</b>	23.40	14.89	100
	Women	20.40	<b>53.06</b>	18.36	8.16	100

Percentage calculated as per the total number of stones attributed by the group to each evaluation criteria associated with a variety disaggregated by gender.

<https://doi.org/10.1371/journal.pstr.0000200.t003>

**Table 4. Men and women farmers' evaluation of African eggplant varieties based on matrix scoring (highest score bold).**

Evaluation criteria (SIAM domains)	Gender	African eggplant varieties				Total (%)
		Neguetan (%)	Keur-bindaw (%)	L10 (%)	Yerekasi (local variety) (%)	
Yield	Men	28.26	<b>30.43</b>	26.08	15.21	100
	Women	22.91	<b>45.83</b>	22.91	8.33	100
Profitability	Men	<b>33.33</b>	26.66	28.88	11.11	100
	Women	32.00	<b>38.00</b>	22.00	8.00	100
Pest and disease resistance	Men	<b>40.00</b>	20.00	20.00	20.00	100
	Women	32.00	<b>38.00</b>	20.00	10.00	100
Consumption	Men	24.48	<b>30.61</b>	24.48	20.40	100
	Women	24.48	<b>34.69</b>	30.61	10.20	100
Taste	Men	<b>32.60</b>	23.91	26.08	17.39	100
	Women	<b>32.65</b>	28.57	28.57	10.20	100

See note to Table 3.

<https://doi.org/10.1371/journal.pstr.0000200.t004>

9.4 ha and 21.2 members). The mean amount of land allocated to tomato and eggplant production was 0.3 ha across all household types (equal to 5.1% of the total average available farmland). Cultivation of both vegetables can be seen as supplementary to grain and cash crops. The lowest average land allocation was among women heads (0.24 ha) and women in monogamous households (0.28 ha). Women and men in polygamous households used 0.32 ha and 0.33 ha respectively. Men in monogamous households reported the highest share of land allocated to tomato and eggplant production (0.55 ha). Given that average land availability was the lowest among monogamous households in our sample, this result calls for further investigation. There was no case in which more than 1 ha was used for the two vegetable crops. In all MHHs, the head was identified as the decision-maker on household land allocation. Only four widowed women reported taking such decisions themselves. Asked about the responsible farm manager (after land allocation), women's responses showed that in the majority of cases they had sole responsibility for production of tomato (83.93%) and eggplant (78.57%). Men's responses often included other household members (such as wives or adult children) as vegetable farm managers. This likely reflects a delegation of labor responsibilities while retaining overall decision-making authority.

**Cropping intensity.** Land allocation is related to the cropping intensity of vegetable production, namely how often a person can produce a crop on the same plot in a year. While 86.84% of men in the sample reported farming tomato and eggplant in both the dry and rainy seasons, this was only true for 49.07% of the women. The remaining 50.93% of women exclusively engaged in dry-season irrigated cultivation. Data from FGDs suggest that decisions on when and how frequently to farm vegetables in a year are contingent on the time a person has available and their access to suitable land. During the rainy season, most crop production is designated to staples and cash crops on household and individual fields. Women have to provide labor for household fields, cultivate their own fields, and attend to domestic tasks and occasional income-generating activities. Women who want to farm vegetables during the rainy season need to not only successfully manage various labor demands, but also negotiate on plot allocation (mainly with the man head). Adult sons may face the same problem, as a woman in Zanzoni explained:

*“Access to land during the rainy season is difficult, even for men. If you do not own land, it is not easy”* (Community of Zanzoni; Women FGD; April 22, 2019).

In dry-season vegetable cultivation, labor demands on other fields and land allocation represented lesser issues. However, access to water and transportation, the task of watering, and the need to protect farmed areas against animals

appeared as new challenges and new labor demands. Membership in a farmers' association was seen as a strong asset in terms of finding land within an infrastructure suited for vegetable farming in the dry period.

**Yield.** Regarding production on the technology parks, yields of all improved tomato varieties in 2019 were significantly higher than the local variety, with *Kologuelen* performing best in N'Golonianasso-Koutiala (29.80 T/ha) and *Bèbi yèrèyé* in Madina-Bougouni (35.50 T/ha). The eggplant variety *L10* yielded most in both technology parks, with significantly higher yields (22.78 T/ha) than the local variety (18.20 T/ha) (Table 5). Yield data from Bougouni, both from farmers' fields and from the technology park of Madina, indicate overall higher productivity of both vegetable varieties in this administrative zone compared with data from Koutiala. This could relate to the more favorable climate conditions for vegetable production in Bougouni than in Koutiala.

In women's and men's evaluations, the tomato variety *Kologuelen* (men: 32.00%; women: 37.25%) and the eggplant variety *Keur-bindaw* (men: 30.43%; women: 45.83%) received the highest scores (Tables 3 and 4). In the discussion, several men expressed their preference for *Kologuelen*, referring to its long storage life as an advantage for marketing. Women pointed at agronomic features of *Kologuelen*, namely its fruit size, shorter growing cycle, and good adaptability to rains during the wet season. The eggplant variety *Keur-bindaw* received a high level of appreciation from women and adult sons in all FGDs. Two women linked the good yield of this variety to its adaptability to different seasonal conditions. Another eggplant variety, *Neguetan*, received the highest score in three FGDs with women, and in one with men. Women indicated that its large fruit size and resistance to plant diseases had a positive effect on yield. Men tended to associate their interest in different varieties' yield with marketability. Yet fruit size and its link to higher market prices was mentioned irrespective of gender and age. Aspects related to farm management featured more clearly in women's evaluations. Results from FGDs in which adult sons took part were more consistent with those of women. The importance women attributed to a variety's adaptability to changing climate conditions can be explained by their limited access to inputs and resources to raise productivity, such as fertilizers, pesticides, water, and good soils. Adult sons, who are similarly subject to the household head's authority over resources as their mothers, may experience comparable constraints. The selection of varieties with shorter growing cycles acts as a time-saving strategy for women who navigate multiple tasks.

Comparing farmers' matrix scoring of varieties under the productivity domain with the average yield measurements on their fields, an alignment of results emerges for tomato varieties. *Kologuelen* stands out as the best performing variety on both men's (25.64 T/ha) and women's (23.42 T/ha) fields. It also received the highest score from both men and women during matrix scoring. Disaggregated by administrative zone and gender, women produced slightly higher yields with *Bèbi yèrèyé* in Bougouni (Table 5). There was less alignment of results for African eggplant varieties. Average on-farm yields

**Table 5. Total yield (T/ha) measured in the technology parks of N'Golonianasso (Koutiala administrative zone) and Madina (Bougouni administrative zone) and average yield recorded in farmers' fields (highest yield bold).**

Experimental variety		Yield in technology parks (T/ha)			Yield in farmers' fields (T/ha)					
		N'golonianasso (Koutiala)	Madina (Bougouni)	Average	Women (N = 56)			Men (N = 19)		
					Koutiala	Bougouni	Average	Koutiala	Bougouni	Average
Tomato variety	<i>Kénéya</i>	26.00	33.77	29.88	15.14	22.38	18.76	22.36	22.99	22.67
	<i>Kologuelen</i>	<b>29.80</b>	32.12	30.69	<b>21.59</b>	25.26	<b>23.42</b>	<b>24.94</b>	<b>26.34</b>	<b>25.64</b>
	<i>Bèbi yèrèyé</i>	28.50	<b>35.50</b>	<b>32.00</b>	18.14	<b>25.99</b>	22.06	23.55	24.73	24.14
	Local variety	18.20	27.47	22.83	13.89	16.47	15.18	14.02	12.94	13.48
African eggplant variety	<i>Neguetan</i>	18.58	24.57	21.57	14.31	21.21	17.76	14.44	<b>20.97</b>	17.70
	<i>Keur-bindaw</i>	17.10	24.61	20.85	14.91	<b>24.25</b>	<b>19.58</b>	16.22	19.77	17.99
	<i>L10</i>	<b>20.14</b>	<b>25.43</b>	<b>22.78</b>	<b>15.70</b>	22.80	19.25	<b>18.18</b>	19.66	<b>18.92</b>
	Local variety	16.88	19.53	18.20	9.48	15.83	12.65	9.08	11.20	10.14

<https://doi.org/10.1371/journal.pstr.0000200.t005>

indicate *L10* as performing best on men's fields (18.92 T/ha), and *Keur-bindaw* as yielding most on women's fields (19.58 T/ha). However, both men and women agreed on *Keur-bindaw* as the most productive African eggplant variety during matrix scoring. [Table 5](#) captures further nuances: *L10* had the highest productivity for both men and women in Koutiala. In Bougouni, women achieved highest yields with *Keur-bindaw*, and men with *Neguétan*. Yield results on farmers' fields (disaggregated by gender) showed tomato yields on men's plots slightly exceeding production on women's plots (with the only exception of the local tomato variety), while African eggplant yield on women's plots exceeded the production of this vegetable on men's plots. However, the small sample size does not allow general conclusions to be drawn on differences in yield performance between fields managed by women and by men.

**Skin hardness (tomato) and storage capacity.** Prolonging the storage life of vegetables was regarded as crucial for meeting sales schedules and limiting post-harvest losses. For tomatoes, generally more perishable than eggplants, we included an evaluation of skin hardness ([Table 3](#)). Both women and men chose the variety *Kologuelen* as performing best for this criterion. However, incautious management at the production stage was depicted as potentially compromising the shelf-life of tomato. Some women observed that excessive application of mineral fertilizer softens the skin and accelerates tomatoes' ripening and rotting, an effect not found for manure. Men involved in vegetable sales reported that buyers travelling long distances for export appreciate hard-skinned tomatoes. On the other hand, a too hard skin was seen as rendering cooking more complicated, as tomatoes would have to be ground into paste instead of chopped.

During FGDs, participants discussed different storage environments to keep yields in good condition. Generally, protections from heat and animals were among the most mentioned aspects. Some women store their tomato harvest in perforated plastic baskets or paper boxes in their houses to keep the fruit uplifted, aerated, and well separated. The fact that thatched roofs are increasingly being replaced with corrugated iron was described as a challenge. As a woman from Madina said:

*"If you store vegetables in metal-roofed storages, they will decay sooner. You need a well-aerated place"* (Community of Madina; Women FGD; April 25, 2019).

One man from the same community circumvented heat-related problems by leaving fruit in the shade of trees. During the survey, farmers' storage capacity was investigated through the question: "How many days can you wait until your tomatoes/eggplants are sold?". Overall, men appeared to have more adequate storage facilities. They were able to wait longer than women, for instance more than 5 days for tomato (26.32% of men; 11.32% of women) or more than 1 week for eggplant (42.11% of men; 6.52% of women). A shorter storage life not only may reduce women's productivity through post-harvest losses, but also can affect their ability to negotiate market prices.

## Economic domain

**Labor allocation in household vegetable production.** Data from FGDs point to little gender differentiation for labor in vegetable production ([Table 6](#)). Fertilizer application, planting, watering, weeding, and harvesting were considered tasks of the person in charge of the individual field, regardless of gender. Stronger gender connotations emerged for ploughing, pesticide application, and processing. Ploughing, partly mechanized, is usually performed by men in the study site. Processing of vegetables was conceptualized as a woman's task. However, as several respondents emphasized, tomatoes and eggplants are mostly sold or consumed without further processing. Data from the survey and FGDs concur that in MHHs, it is mainly men heads or adult sons who apply pesticides. Asked about who usually does the spraying, men heads (37.68%) received most indications, followed by adult children (18.84%), and wives (17.39%). Less significant was joint labor, support by relatives, or by men members of the cooperative to which some women producers belonged. Causes and implications of men's greater involvement in pesticide application are detailed under the environmental and human domains.

**Table 6. Household labor allocation in vegetable production (collated from FGDs).**

Task	Task of individual field manager	Task predominantly carried out by	
		Women	Men
Ploughing			X
Fertilizer application	X		
Planting	X		
Watering	X		
Weeding	X		
Pesticide application			X
Harvesting	X		
Processing		X	

<https://doi.org/10.1371/journal.pstr.0000200.t006>

**Profitability.** When scoring the profitability of varieties, farmers highlighted characteristics that make them appealing to customers. Among tomato varieties, *Kologuelen* received the highest score from both women (44.89%) and men (46.80%) (Table 3). Men underlined its appreciable taste, its shade of red, and its large fruit size as justifications for a higher market price. Women mentioned *Kologuelen's* attractive fruit pulp. The variety's hardness of skin, as evaluated in the productivity domain, was again brought up as increasing sales. For eggplant, taste as well as fruit appearance (a combination of size, pulp, and color) were identified as major drivers for customers' preferences. However, additional aspects were brought into play during scoring. As a result, men preferred *Neguetan* (33.33%) and women *Keur-bindaw* (38.00%) (Table 4). *Neguetan* was appreciated for its price stability during the year, and its good appearance in the eyes of clients. Women gave the highest score to *Keur-bindaw* despite its low market price (compared with other varieties), given its small fruit size. This preference was explained by *Keur-Bindaw's* yield over a long period of time, which allows women to sell little by little to gain a steady income. In this respect, the secure availability of marketable produce outweighed other considerations.

**Household decision-making on income from vegetable sales.** Survey data from MHHs (Table 7) suggest that individual field managers largely take sole decisions on the income they generate from tomato and eggplant sales. Men indicated that they involved spouses and adult children in decisions more frequently than women, a finding that could be explained by more joint management on men's vegetable fields, as outlined under land allocation (productivity domain). This indication, however, was not confirmed in all FGDs. For instance, a group of adult sons from N'Golonianasso stated that their fathers hold sole control over vegetable income in spite of their labor contributions in the fields. In this scenario, adult sons appeared as helpers with little or no share in revenue-related decisions. It remains open how far women

**Table 7. Decision-making on income from tomato and eggplant sales in man-headed households by gender of respondent.**

Who decides on income from tomato/eggplant sales?	Respondent			
	Women		Men	
	Tomato	Eggplant	Tomato	Eggplant
Husband	18.53	20.85	63.18	63.18
Husband; wife	3.70	4.16	5.26	5.26
Husband; wife; adult child	0.00	0.00	5.26	5.26
Husband; adult child	0.00	0.00	15.78	15.78
Wife	75.92	72.91	10.52	10.52
Wife; adult child	1.85	2.08	0.00	0.00
TOTAL (%)	100.00	100.00	100.00	100.00

<https://doi.org/10.1371/journal.pstr.0000200.t007>

involve adult children in income decisions after having received their support. Generally, women reported having a high level of control over money from vegetable sales. A few of them, however, said they let their husband know about their revenue. This can be interpreted in different ways: showing the income could represent a gesture of transparency and deference towards the husband, who formally holds control over most household expenditures. Alternatively, it could result from a woman's wish to demonstrate her ability to generate income. Meeting expenditure was regarded as a matter of personal pride, as a woman from Madina expressed:

[With our money] *We purchase soap and meet the small needs of our children for them to not bother their fathers. Having money for ourselves makes us proud as it prevents us from humiliation* (Community of Madina; Women FGD; April 25, 2019).

In farmers' discussions, a strong correspondence emerged between expenditure using vegetable revenue and gendered responsibilities within households. Condiments and clothes were commonly covered by women. Health consultations and medicines were mentioned as within men's responsibility. School kits could be paid for from either men's or women's pockets. In general, married women indicated that they rarely buy food with a market value exceeding that of condiments, except for occasional purchases of meat, fish, or spaghetti. Husbands were regarded as responsible for providing staple crops from household fields. All in all, income from vegetable sales was seldom used to meet basic consumption needs. This result is also seen in the human domain. Both women and men said that they give part of their vegetable harvest in kind to friends or relatives. This exchange creates benefits beyond income, and needs to be investigated further.

**Marketing strategies for tomato and eggplant.** With regard to how farmers determine sales prices, patterns for eggplant and tomato appeared similar. Also, there were no notable gender differences in decision-making on prices. Almost 80% of the women and 90% of the men indicated that they knew the crop's price and negotiated for it. Members of producer cooperatives took decisions on sales prices at the group level.

In the survey question on marketing locations, response options included larger marketplaces, as well as sales to buyers from the same or other communities (with multiple responses allowed). Among farmers who grow tomato and eggplant for sale, larger marketplaces were the most frequented sales locations, even more so for men (89.47%) than for women (67.94%). Same-community sales emerged as the second most important option (57.89% for men, 58.50% for women), while sales in other communities were least popular (10.52% for men, 16.99% for women). Mixed marketing strategies were common, the combination of same-community and larger marketplace sales leading the list (47.37% of the men and 32.08% of the women). Overall, women showed weaker engagement in larger markets. However, respondents from polygamous households had a stronger tendency to frequent larger markets than those from other household types. This could be explained by the larger household size of polygamous arrangements, with greater capacity to mobilize other members for support in vegetable sales or in overseeing domestic tasks.

For the physical act of taking vegetables to the market, women were most active across all household arrangements and vegetable crops. In a multiple response question, respondents from MHHs indicated the lowest involvement of the head (22.38%), stronger involvement of adult children (51.22%), and the highest involvement of the wife (65.51%), with no important differences for tomato and eggplants. Men producers tended to send an adult child or their wives, while women marketed themselves or sought help from adult children. Social norms may account for the high level of support children provide to their parents, and the low expectation towards men to help their wives compared with women's support for their husbands. Information from FGDs lends nuance to the survey results. For instance, a group of women in Madina highlighted difficulties in accessing marketplaces further away, forcing them to sell within their own community.

Woman 1: *It is not easy to access the market.*

Facilitator: *Where do you sell then?*

Woman 2: *Here in the village.*

Woman 3: *This year, T. [a man from the same community] found a client for us in Bougouni. Finally, this man came but only once. This is why we [have decided to] harvest and sell among each other in our community.*

Woman 4: *A project had given us two donkey carts. We collected all our products and sent two people to go and sell and come back with the money for us all. But then the donkeys got sick, and the carts got damaged. We would wish to gain two tricycles for our sales.*

(Community of Madina; Women FGD; April 25, 2019).

Women reported more constraints than men in terms of transport facilities. The attempt to arrange collective sales speaks to the difficulty of managing market sales on an individual basis. This suggests that women's engagement in larger markets does not automatically imply smooth logistics. Sales and transport arrangements seemed precarious and likely to fail easily.

## Environmental domain

**Disease and pest resistance.** The matrix scoring exercise sheds light on women's and men's different perceptions of disease and pest resistance of the tomato and eggplant varieties. During tomato evaluations, most men and women considered *Bèbi yèrèyé* as most resistant against pests, diseases, and water shortages. *Kénéya* was equally appreciated by women (Table 3). When commenting on *Kologuelen*'s lower scoring, respondents pointed at this variety's high susceptibility to pests and the need for precautionary measures to preserve it from rotting during the fruiting period. Also, several women and men mentioned *Kologuelen*'s vulnerability to a pest locally known as *toumou* (*Helicoverpa armigera*). Despite these shortcomings, some farmers regarded efforts at protecting *Kologuelen* against pests and diseases as compensated for at the times of sale. This is illustrated by the following quotation from a woman from Dieba:

*"I give three stones to Kologuelen as the few fruits it yields despite its susceptibility bring some money"* (Community of Dieba; Women FGD; April 24, 2019).

This corresponds with farmers' evaluation of *Kologuelen* as the most profitable variety (see economic domain). For eggplant, women established *Keur-bindaw* as the most resistant variety, although it is more susceptible to water shortages than other varieties. Men attributed a higher score to *Neguetan* (Table 4). Two respondents from Madina underlined *Neguetan*'s remarkable resistance to a common spider mite known as *n'guaragua bleni* (*Tetranychidae*), a type of arachnid that can be identified through careful inspection of the eggplant leaves. How these assessments of resistance relate to pesticide use is outlined below.

**Use of pesticides.** Chemical pesticides (pyrethroid insecticides) as well as biopesticides (prepared with neem leaf extracts) were commonly used in the study sites. Farmers' pesticide use patterns were similar across both vegetable crops. Asked whether they spray chemical pesticides, biopesticides, both, or none, only a few women reported no use of pesticides at all (12.96% for tomato; 8.33% for eggplant). Approximately one third of the women employed chemical pesticides, while another third used biological pesticides. Among men, a combination of chemicals and biopesticides was more common (47.37% for both vegetables) than among women. How the selection of pesticides relates to men's more frequent participation in training and practical involvement in spraying needs further investigation (see economic and human domains). Data from the FGDs indicate that men are regarded as holding the knowledge in that field. On the other hand, women were perceived as having the ability to better detect plant diseases or other threats to plant growth that might require pesticide application. This is shown by the following quotation from a discussion in Zanzoni:

*It is the men who spray. But women usually make more considerations than men. Whenever they detect a [plant] disease they tell us, and we spray* (Community of Zanzoni; Men FGD; April 22, 2019).

For financial and health reasons, especially women farmers discussed alternatives to chemical pesticides. Biopesticides were praised because materials for their preparation are easily procurable and cheap. Residues of biopesticides were seen as less harmful, especially when vegetables cannot be properly washed. Some women also mentioned that they prevent pests by staking tomato with dried sorghum stalks.

**Access to water.** Access to water for vegetable irrigation was an important concern for respondents. In the study sites, water shortages often occur in March and April. Wells quickly dry out due to their shallowness. Farmers preferred water pumps, arguing that their depth would protect groundwater not only from evaporation, but also from polluting agents. However, the FGDs revealed that coping strategies against water shortages were gendered. Several men mentioned water purchases as a viable solution during drought peaks. In this case, water committees at the municipality level would sell water, a person's purchasing power determining the amount that could be obtained. This option was not explicitly mentioned by women. Whether this relates to financial constraints would need further investigation. Most women reported accessing the closest pump with a donkey cart, sometimes in vain. Walking or driving longer distances and waiting at the pump was described as time-consuming, forcing women at times to temporarily suspend their farming activities:

*We fetch the water from the pump, but sometimes we are too many and the water is not enough. If you cannot get to the pump today, [you will suspend your work and] tomorrow you will pick it from where you left it the day before. We are having this problem (Community of Madina; Women FGD; April 25, 2019).*

Delayed irrigation was seen as a risk for vegetable growth. To limit this risk, some women decreased their vegetable production to a land size manageable for irrigation, despite the larger land sizes they had access to. Gendered coping strategies during drought peaks are related to access to income, time constraints, labor burdens, and access to fertilizers to increase soil moisture content.

**Use of fertilizers.** Fertilizer options in the study sites included animal-based manure, plant-based manure, mineral fertilizer (urea, NPK), and combinations of these. Asked about fertilizer use under non-experimental conditions, most women and men said that they apply combinations of different fertilizer options, except for a small number of women in MHHs (10%) who made sole use of animal-based manure. None of the respondents cultivated vegetables with no fertilizer at all. Almost all men (94.74%) mixed mineral fertilizer with animal-based and/or plant-based manure. The same was true for only 55.36% of the women farmers, the remaining 44.64% exclusively spreading a mixture of animal- and plant-based manure. Most adult sons said that they purchase mineral fertilizer. Women living in polygamous arrangements more frequently relied on mineral fertilizer than women in monogamous units, probably due to input sharing with other household members. In FGD discussions, both women and men complained about high prices of mineral fertilizers and described manuring as a cost-saving strategy. A group of men who formed part of a local cotton producer association in Zanzoni explained that their membership allowed them to request credits for fertilizer purchases. As none of the women respondents in this site belonged to the cotton producer association, they could not benefit from this opportunity. However, in the same community, widowed women resorted to collective purchases of mineral fertilizer during the dry season (when market prices are low) to cut costs.

## Human domain

**Consumption.** In the survey, respondents were asked to indicate whether they cultivate vegetables for home consumption, cash income, or both. Almost all women and men farmed for both purposes (93.15% for tomato; 97.01% for eggplant). The proportion of the harvest allocated to consumption was 41.56% for tomato and 39.77% for eggplant. For these results, there were no important differences between genders, or between respondents living in various household arrangements. A stronger sales orientation of men (see productivity domain) or consumption orientation of women based on their obligation to provide sauce crops was not confirmed at this point.

When tomato varieties were evaluated in terms of consumption, most women and men preferred *Kologuelen* (Table 3). This was explained by the high versatility of this variety in meal preparation. *Kologuelen* was reported to be consumed raw and cooked, used to season salads and sauces, and was very much praised for its taste. On the other hand, some women commended the local variety for its pulp density, which made it particularly suitable for sauce preparation. In some cases, these preferences were less important for determining the variety most consumed: for example, a group of women from Dieba mainly consumed *Bèbi yèrèyé* because of low market prices due to the good harvest of this variety. Among eggplant varieties, *Keur-bindaw* received the highest score from women as well as from men (Table 4). They also appreciated *Neguetan* and *L10* for their multiple uses in domestic meals. One woman pointed at *Neguetan*'s high market price as making it more attractive for sales and less for consumption. *Keur-bindaw* was lauded for the soft consistency it gained during cooking.

**Taste preferences (African eggplant).** Matrix scoring of taste in eggplants aimed at assessing the degree of bitterness of each variety and its relative appreciation. Women and men scored *Neguetan* as the tastiest among all varieties, agreeing on its sweeter flavor and lower degree of bitterness (Table 4). When discussing the variety *Keur-bindaw*, women in Madina reported that bitter varieties are mainly consumed in sauces, probably because the bitterness can be reduced during processing and counterbalanced with other ingredients. Taste was also considered as an important driver for client's eggplant preferences, as a woman pointed out:

*If clients buy eggplant from you one time and they realize that it is too bitter, next time they will go to another seller. They will tell that those eggplants don't taste good* (Community of N'Golonianasso; Women FGD; April 23, 2019).

At this point a relationship emerged between taste preferences, household consumption, and market-oriented production, as the case of *Neguetan* shows. As the most popular variety in terms of taste, *Neguetan* is highly profitable in the market. Farmers trade-off home consumption of this preferred variety against increases in income, taking additional aspects into account. As outlined in the economic domain, men scored *Neguetan* as the most profitable, while women appreciated a lower yet steadier income from *Keur-bindaw* (Table 4).

**Participation in training on pesticide use.** In the SIAF, the capacity to experiment at the household level (based on training) is allocated to the human domain. At the start of the vegetable activity, most of the participating men had already received training on pesticide production and application as part of a long-standing local cotton farming project. Africa RISING introduced and trained farmers on the preparation and use of biopesticides based on neem oil. When this specific training for vegetable farming was evaluated, a gender bias again became visible. A multiple response question on who in the household had attended the training resulted in 56.00% of indications for men heads, 25.34% for women, and 21.34% for adult children (MHHs only). In polygamous households, there was more participation by women, and specifically more joint participation by men and women from the same household, than in monogamous arrangements. A possible explanation for men's stronger engagement in pesticide training as compared to women could be underlying gender norms that also inform task allocation in farming (see economic domain). This aspect was raised several times during FGDs and was particularly supported by men:

*The men usually do [spray pesticides], but not always the same person. But we don't accept that women do that. Some women have been trained on pesticide application techniques, but we believe that anything that is dangerous shall be handled by men* (Community of Zanzoni; Men FGD; April 22, 2019).

The perceived danger of pesticide application and supposed "inability" of women to deal with it accounts for the fact that spraying is one of the exceptions to the allocation of labor tasks to the field manager irrespective of gender (Table 6), as the following quotation illustrates:

Man 1: *The one who farms also does the spraying.*

Facilitator: *Ok. And what if it is a woman?*

Man 1: *In that case, she will look for a man to do it.*

Man 2: *A woman doesn't use pesticide here in our place.*

(Community of N'Golonianasso; Men FGD; April 23, 2019)

Men who highlighted the danger of pesticide exposure reinforced their superiority in the normative order and refused to acknowledge women's experience and knowledge in this field. As a result, participation in training does not guarantee women hands-on involvement in pesticide application. In contrast to men, women had a more nuanced understanding of their own abilities and knowledge. While often relying on men for spraying, most of the women claimed to possess knowledge in pesticide production and use, specifically for biopesticides. Even exclusion from training was not seen as a valid justification for being considered inexperienced in this field, as a woman pointed out:

*"We haven't received any (formal) training but the instructions we receive are a training as well"* (Community of N'Golonianasso; Women FGD; April 23, 2019).

Despite this, many women expressed their wish to be included in formal training opportunities to complement their knowledge.

## Social domain

**Participation in farmers' associations.** All except two women and two men were members of local farmers' associations. Membership was considered an advantage since associations often hold larger community gardens. Smaller plots are allocated to members for vegetable production. Where associations are in need of additional land, requests to the local administration can be put forward by the group.

*[To get access to land] we ask the mayor to give us some space for gardening [...] What we produce normally belongs to us, but not the land. It's a request.* (Community of N'Golonianasso; Women FGD; April 23, 2019)

Also, members of associations can collectively purchase fertilizer and pesticides. Gains from collective vegetable sales are partly reinvested in the gardens' maintenance, and divided among group members for private use. Two women from Madina pointed at the additional advantage of pooling money within the group for farming and other expenses:

Woman 1: *After the sales we wanted to pool our money to meet given expenditures and to loan ploughs to clear the plots together.*

Woman 2: *We do the tontine [money pooling system] within our association to support each other and keep us united.* (Community of Madina; Women FGD; April 25, 2019).

Although group membership was seen as an asset in terms of access to resources and inputs, not all respondents seemed to benefit equally from the collectives' opportunities. Limited access to household income may put women into a situation where reduced input prices for association members are still unaffordable (see environment domain). Social dynamics and gender relations in households and farmers' associations at the community level – and the interactions between both – would merit further investigation.

## Discussion

For an overall discussion of the gender implications and sustainability of the vegetable innovation bundles, we build upon the gender-transformative approach for breeding outlined in the introduction. This approach actively seeks to address inequalities by placing an emphasis on the traits that women demand and combining varietal improvements with other

innovations that increase equity within gendered production relations [13]. A similar distinction between evaluating a technology (e.g., a variety, a machine) through a gender lens, and assessing the enabling or limiting production conditions for women and men, has been applied for the SIAF [24]. Here we discuss gendered trait preferences, conditions – conducive or constraining – in terms of equity, and linkages between preferences and conditions, wherever they became visible. We then offer recommendations for development initiatives that want to pursue a gender-transformative approach to scaling innovation bundles for vegetable farming in the specific Malian context. The idea of bundling technical and social innovations for improved scaling and sustainability is in line with Sartas et al. [45].

### Productivity domain

Analysis in the productivity domain reveals that women and men preferred the same tomato and eggplant varieties in terms of yield. However, underlying drivers for the same preferences may be different [19]. While men emphasized *Kologuelen's* (tomato) and *Keur-Bindaw's* (eggplant) advantages for marketing, women praised the same varieties' favorable agronomic features. Men's preferences for market-related benefits of high-yielding varieties could indicate a higher interest in vegetable sales. Women's preferences mirror gender norms that limit their room to maneuver to achieve higher yields, such as shorter growing cycle and resistance to abiotic stress. At the household and community levels, norms allow men to fare better in competition for (fertile) land. In MHHs, heads are the primary decision-makers on land allocation for agricultural production. Other scholars describe men farmers' successful appropriation of low-lying vegetable gardens (with access to irrigation) and their better access to resources that increase productivity [27,34,35]. Imbalanced power relations and labor burdens constrain cropping intensity on women's vegetable fields. Women's inadequate storage facilities may lead to post-harvest losses. How far intra-household discussions and power relations influence individual plot managers' seed variety selection has not been addressed by this study and remains an important topic for future research.

Recommendations:

- To address women's constrained access to land, the introduction of high-yielding tomato and eggplant varieties should go hand-in-hand with transformative innovations, such as negotiations of intra-household land tenure arrangements. Stiem-Bhatia and Koudougou [46] showcase how land use rights for women in Burkina Faso can be secured through innovative village level negotiations that build upon existing systems of land governance. The MAST (Mobile Applications to Secure Tenure) suite of tools [47], developed and piloted by USAID in Burkina Faso and other countries, could also be considered. Mobile applications support and simplify participatory processes of land registration with a specific focus on women's land rights. Better access for women to communal vegetable gardens should be strengthened through collective action groups.
- To reduce women (and men) farmers' post-harvest losses, low-cost storage facilities for vegetables should be developed and disseminated. They should meet differential demands and be easy to build after training. Clay pot coolers made from locally available inexpensive materials are an example that has been tested with vegetable producers in Mali [48].

### Economic domain

Drivers for varietal preferences were less distinctive in the economic domain. However, in terms of eggplant varieties, men preferred *Neguetan* for its price stability and attractiveness for customers, while women favored *Keur-Bindaw* that allows for a long seasonality of picking to generate small income amounts. The latter result could be interpreted in the light of Turriffin [49] and Baden [50]. They describe how especially younger women engage in regular small-scale trade of their own produce, while elderly women – freed of domestic chores – tend to have a larger portfolio of income-generating activities. Overall, cultural norms governing appropriate marketing activities are to the advantage of men, and are compounded by men's better access to transport, as our data show. Inequitable production relations manifest themselves in a paradox: women's high autonomy to initiate their own activities and control income is confronted with multiple constraints (high

labor burden, limited access to resources, inadequate storage) and often results in low profitability. Limited income is still ploughed back into the household to meet gendered responsibilities, a situation also described by Simard [51] a quarter of a century ago. Adult children contribute labor to their parents' individual vegetable fields and help with taking produce to the market. However, their gains and voice in these processes remain contested. The commercial potential of the investigated initiative after two years of experimentation would have to be assessed through a follow-up study. Important questions would be how far women or men farmers have maintained or increased their production and sale of the tomato and eggplant varieties within the enabling or limiting conditions described.

Recommendations:

- To raise women's profitability of vegetable production, initiatives should foster collective action groups for gaining credit, purchasing inputs, marketing produce, and arranging transport [50,52]. However, Baden's [50] evaluation of such groups in Mali shows that the majority of group members still sold produce on an individual basis. Women's financial household responsibilities required more regular and flexible income flows than common groups could provide. Initiatives should generate space for existing or new groups to assess how they could better align with the demands of different women members, including small-scale traders.
- To transform inequitable household relations with respect to income and labor, household methodologies such as the Gender Action Learning System (GALS) should be used. GALS jointly engages men, women, and adult children in reflections on how more equitable income and labor contributions to their households could be achieved [53]. With regard to women, lower labor burdens, more own income, or access to other household members' income to buy inputs could make their gardening activities profitable in a sustainable way. Purchases of improved seeds (regarded as expensive by our respondents) could become affordable. In the long run this could lead to new varietal preferences among women (and men) vegetable farmers.

## Environmental domain

In the environmental domain, women and men agreed on the most resistant tomato variety in terms of pests, diseases, and water shortages – *Bèbi yèrèyé*. Although *Kologuelen* was scored as the highest yielding, tastiest, most profitable, and most consumed variety, it was seen as more susceptible to pests and diseases than *Bèbi yèrèyé*. This is an important trade-off for farmers that breeders should consider. Men and women disagreed with respect to the most resistant eggplant variety, a result that needs further investigation. All in all, women appeared disadvantaged compared with men when looking at the natural resource base available to them for vegetable production, including pest management and fertilizers. As other studies indicate, women in Mali often farm on less fertile land [9] or compete unsuccessfully with men for gardening spaces suitable for irrigation [34]. Women's limited purchasing power undermines efforts to compensate for this – an interconnection between the economic and environmental domains. Access and use of chemical fertilizers emerged as lower among women than men farmers. Some men in the sample benefitted from credits for inputs issued by a local cotton company [cf. 9]. Several men pointed at water purchases as a viable solution in the face of drought. Women's coping strategies did not envisage any financial outlay of this kind. For financial (and health) reasons, women preferred biopesticides. Men are strongly involved in formal pesticide training, while women rely more on informal sources to acquire knowledge in this field, a result which is in line with Christie et al. [35], and is further discussed below under the human domain. Amidst these constraints, women may be less able than men to adopt climate adaptation strategies [54].

Recommendations:

- To improve women's access to fertilizers, initiatives that support varietal improvement should include collective arrangements for fertilizer purchases and the production of biofertilizers. Decisions should be taken for specific contexts on whether women-only or mixed gender groups are best suited for this purpose [50].

- To respond to women’s demand for biopesticides, training in biopesticide production and application from locally available, affordable resources should be further promoted. Skills may be beneficial beyond immediate use in the fields of those who participated in training: for example, Tamò [55] provides examples of how women’s groups, NGOs, and start-up enterprises can generate income from local biopesticide production. He also calls for the development of appropriate training materials to ensure quality control of products.

### Human domain

In the human domain, the high prevalence of vegetable production for both home consumption and income generation creates room for trade-offs. For both vegetables, around 40% of the harvest was allocated to consumption. Taste and versatility in meal preparation, as well as customer demand, mattered for both men and women farmers’ decisions on whether to consume or sell a variety. There were indications that *Neguetan*, considered the tastiest African eggplant variety, was sometimes more likely to be sold than consumed at home. Some women used the tomato variety *Bèbi yèrèyé* for meal preparation at home because they could not get good prices for it in the market. *Bèbi yèrèyé* is a variety bred for high vitamin A content, which customers find hard to accept for its orange-colored skin. Wooten [34] fears that the commercialization of vegetable production in Mali may lead to changes in local culinary patterns, and a situation in which especially men producers forfeit the nutritional value of their own meals for income. These fears could not be confirmed by our data in a straightforward manner; however, the question Wooten raises remains important for further investigation. Overall, improving producers’ and customers’ diets through incorporating vegetables demands not only broader dissemination of information on nutritional properties, but also sufficient levels of income security (especially among farmers). Future studies should also address gendered preferences for nutritional outcomes of different varieties. Another important result of the human domain is that gender norms favor men’s stronger involvement in pesticide training and application. Emphasizing the dangers of pesticide exposure and the supposed “inability” of women to deal with it allowed men respondents to claim their superiority and to justify the exclusion of women from formal training opportunities.

Recommendation:

- To transform inequitable gender norms concerning pesticide application, new pesticide training formats should be developed to which husbands and wives, or several household members, are invited. GALS tools or other household methodologies [53] can be used to combine reflection sessions on restrictive gender norms with sessions on pesticide production and application. This will not only reduce women’s dependence on men’s labor for pesticide use, but also strengthen men’s trust in women’s abilities. To be truly accessible, new formats must consider women’s educational levels, their daily routines, and conducive venues. Where women-only groups constitute a preferred platform for learning, existing women’s organizations could be an important entry point [35,56].

### Social domain

In the social domain, our results suggest that membership in farmers’ associations can result in advantages in terms of access to land, inputs, collective sales arrangements, and rotating funds. However, gendered constraints at the household level may restrict women from taking full advantage of opportunities in their association. Gender dynamics in farmers’ associations were not investigated in this study, but merit further attention.

Recommendation:

- To support women and men farmers in an equitable manner, farmers’ associations should embark on processes to combat institutional gender inequalities. A current example is the Dou Toulouma project in Mali (launched in 2021), through which Canada Aid in cooperation with partners seeks to strengthen the gender capacities of farmers’

cooperatives and their unions [57]. The overall aim is to improve leadership and representation of women in decision-making bodies, and to provide products and services that are better adapted to women farmers.

## Conclusion

This study explores genetically intensified vegetable production in southern Mali, linking varietal preferences to the gender relations in which production is embedded at the household, community, and market scales in order to arrive at recommendations for future work. Questions of social justice, such as the equitable allocation of agricultural resources, emerge as central for the sustainability of vegetable farming. Large-scale processes, such as climate change and population pressure, lend further significance to the link between equity and sustainability. Building climate resilience depends on fair household decision-making, balanced labor burdens, and access to agricultural resources.

Farmers' gendered preferences make visible how varieties fit with existing inequitable structures. To make breeding transformative, varieties have to be developed with gender equality in mind and packaged with innovations that create production, consumption and income-generating opportunities previously beyond the reach of disadvantaged groups, particularly women [13,18–20]. Further research should explore how transformative measures at multiple scales, including policy and government, can contribute to equity and resilience in Malian farming communities. Where transformative measures and breeding go hand-in-hand, progress towards the Sustainable Development Goals can be achieved.

## Author contributions

**Conceptualization:** Gundula Fischer, Jean-Baptiste Tignegre.

**Formal analysis:** Martina Cavicchioli, Alpha-Sidy Traore, Kipo Jimah, Simon Wittich.

**Investigation:** Alpha-Sidy Traore, Mahamadou Dicko.

**Methodology:** Gundula Fischer, Alpha-Sidy Traore, Kipo Jimah.

**Validation:** Alpha-Sidy Traore, Felix Badolo, Chiaka Diallo.

**Writing – original draft:** Martina Cavicchioli.

**Writing – review & editing:** Gundula Fischer, Martina Cavicchioli.

## References

1. Afari-Sefa V, Tenkouano A, Ojiewo CO, Keatinge JDH, d'A Hughes J. Vegetable breeding in Africa: constraints, complexity and contributions toward achieving food and nutritional security. *Food Sec.* 2012;4(1):115–27.
2. Dinssa FF, Hanson P, Dubois T, Tenkouano A, Stoilova T, Hughes JDA. AVRDC - the World Vegetable Center's women-oriented improvement and development strategy for traditional African vegetables in sub-Saharan Africa. *Eur J Hortic Sci.* 2016;81(2):91–105.
3. Schreinemachers P, Simmons EB, Wopereis MCS. Tapping the economic and nutritional power of vegetables. *Glob Food Sec.* 2018;16:36–45. <https://doi.org/10.1016/j.gfs.2017.09.005>
4. Depenbusch L, Schreinemachers P, Roothaert R, Namazzi S, Onyango C, Bongole S, et al. Impact of home garden interventions in East Africa: Results of three randomized controlled trials. *Food Policy.* 2021;104:102140. <https://doi.org/10.1016/j.foodpol.2021.102140>
5. World Vegetable Center. The World Vegetable Center's Approach to Household Gardening for Nutrition. Shanhua, Taiwan: World Vegetable Center; 2016. <https://avrdc.org/wpfb-file/eb0270-pdf/>
6. Montpellier Panel. Sustainable Intensification: A New Paradigm for African Agriculture. London: Imperial College London; 2013. <https://ag4impact.org/wp-content/uploads/2014/07/Montpellier-Panel-Report-2013-Sustainable-Intensification-A-New-Paradigm-for-African-Agriculture-1.pdf>
7. Haggard J, Nelson V, Lamboll R, Rodenburg J. Understanding and informing decisions on Sustainable Agricultural Intensification in Sub-Saharan Africa. *Int J Agric Sustain.* 2020;19(5–6):349–58. <https://doi.org/10.1080/14735903.2020.1818483>
8. Loos J, Abson DJ, Chappell MJ, Hanspach J, Mikulcak F, Tichit M, et al. Putting meaning back into “sustainable intensification”. *Front Ecol Environ.* 2014;12(6):356–61. <https://doi.org/10.1890/130157>
9. Tufan HA, Grando S, Meola C. State of the Knowledge for Gender in Breeding: Case Studies for Practitioners. Lima, Peru: CGIAR Gender and Breeding Initiative; 2018.

10. Fisher M, Carr E. The influence of gendered roles and responsibilities on the adoption of technologies that mitigate drought risk: The case of drought-tolerant maize seed in eastern Uganda. *Glob Environ Change*. 2015;35:82–92.
11. Polar V, Mohan RR, McDougall C, Teeken B, Mulema AA, Marimo P. Examining choice to advance gender equality in breeding research. In: Pyburn R, van Eerdewijk A, editors. *Advancing gender equality through agricultural and environmental research*. Washington DC: International Food Policy Research Institute (IFPRI); 2021. pp. 77–111.
12. IGWG. Gender integration continuum. Washington D.C.: Interagency Gender Working Group; 2017. [https://www.igwg.org/wp-content/uploads/2017/05/FG\\_GendrIntegrContinuum.pdf](https://www.igwg.org/wp-content/uploads/2017/05/FG_GendrIntegrContinuum.pdf)
13. Orr A, Cox CM, Ru Y, Ashby J. *Gender and social targeting in plant breeding*. Lima (Peru); 2018.
14. Galiè A. Empowering women farmers: the case of participatory plant breeding in ten syrian households. *Front: J Women Stud*. 2013;34(1):58–92.
15. Farnworth CR, Badstue L, Williams GJ, Tegbaru A, Gaya HIM. Unequal partners: associations between power, agency and benefits among women and men maize farmers in Nigeria. *Gender Technol Dev*. 2020;24(3):271–96. <https://doi.org/10.1080/09718524.2020.1794607>
16. Darmstadt GL, Heise L, Gupta GR, Henry S, Cislighi B, Greene ME. Why now for a Series on gender equality, norms, and health? *Lancet*. 2019;393(10189):2374–7.
17. Badstue L, Elias M, Kommerell V, Petesch P, Prain G, Pyburn R. Making room for manoeuvre: addressing gender norms to strengthen the enabling environment for agricultural innovation. *Dev Pract*. 2020;30(4):541–7.
18. Cavicchioli M, Cole SM, Teeken B, Ashby J, Polar V, Kramer B. Contextualizing women’s and men’s trait preferences and choice options in the uptake of breeding products: A framework. Ibadan, Nigeria: International Institute of Tropical Agriculture (IITA); 2023.
19. Tegbaru A, Menkir A, Nasser Baco M, Idrisou L, Sissoko D, Eytayo AO. Addressing gendered varietal and trait preferences in West African maize. *World Dev Perspec*. 2020;20:100268.
20. Nchanji EB, Lutomia CK, Ageyo OC, Karanja D, Kamau E. Gender-Responsive Participatory Variety Selection in Kenya: Implications for Common Bean (*Phaseolus vulgaris* L.) Breeding in Kenya. *Sustainability*. 2021;13(23):13164. <https://doi.org/10.3390/su132313164>
21. Musumba M, Grabowski P, Palm CA, Snapp SS. Guide for the sustainable intensification assessment framework [Internet]. Kansas, USA: Kansas State University; 2017 [cited 2023 Oct 18]. Available from: <https://cgspace.cgiar.org/handle/10568/90523>
22. Hammond J, van Wijk M, Teufel N, Mekonnen K, Thorne P. Assessing smallholder sustainable intensification in the Ethiopian highlands. *Agric Syst*. 2021;194:103266. <https://doi.org/10.1016/j.agry.2021.103266>
23. Abdul Rahman N, Larbi A, Kotu B, Kizito F, Hoeschle-Zeledon I. Evaluating sustainable intensification of groundnut production in Northern Ghana using the sustainable intensification assessment framework approach. *Sustainability*. 2020;12(15):5970. <https://doi.org/10.3390/su12155970>
24. Fischer G, Wittich S, Malima G, Sikumba G, Lukuyu B, Ngunga D. Gender and mechanization: exploring the sustainability of mechanized forage chopping in Tanzania. *J Rural Stud*. 2018;64:112–22.
25. Kihara J, Manda J, Kimaro A, Swai E, Mutungi C, Kinyua M. Contributions of integrated soil fertility management (ISFM) to various sustainable intensification impact domains in Tanzania. *Agric Syst*. 2022;203:103496.
26. Fischer G, Jimah K, Mumuni E, Nurudeen AR, Glover K, Weseh A. Developing gender-transformative innovation packages for sustainable intensification: the case of maize leaf stripping in northern Ghana. *Gender Technol Dev*. 2023;28(1):1–28. <https://doi.org/10.1080/09718524.2023.2260652>
27. Wooten S. Women, men, and market gardens: gender relations and income generation in rural Mali. *Hum Organ*. 2003;62(2):166–77. <https://doi.org/10.17730/humo.62.2.b5gew5paf8qer3q0>
28. Becker LC. The Collapse of the Family Farm in West Africa? Evidence from Mali. *Geogr J*. 1990;156(3):313. <https://doi.org/10.2307/635532>
29. De Groot H, Coulibaly N. Gender and generation: an intra-household analysis on access to resources in Southern Mali. *Afr Crop Sci J*. 1998;6(1). <https://doi.org/10.4314/acsj.v6i1.27827>
30. Polak B. *Die Könige der Feldarbeit: Das Arbeitshandeln von Bamana-Bauern (Kinder, Frauen und Männer) in Mali*. Bayreuth: Universität Bayreuth; 2016.
31. Hilhorst T, Toulmin C. *Sustainability Amidst Diversity: Options for rural households in Mali* [Internet]. IER, IDS & IIED. International Institute for Environment and Development. 2000. [cited 2025 Mar 3]. Available from: <https://www.iiied.org/x185iied>
32. Smale M, Assima A, Kergna A, Thériault V, Weltzien E. Farm family effects of adopting improved and hybrid sorghum seed in the Sudan Savanna of West Africa. *Food Policy*. 2018;74:162–71. <https://doi.org/10.1016/j.foodpol.2018.01.001> PMID: 29479132
33. Rattunde F, Sidibé M, Diallo B, van der Broek E, Somé H, vom Brocke K. Involving women farmers in variety evaluations of a “men’s crop”: Consequences for the sorghum breeding strategy and farmer empowerment in Mali. In: Tufan HA, Grando S, Meola C, editors. *State of the Knowledge for Gender in Breeding: Case Studies for Practitioners*. Lima, Peru: CGIAR Gender and Breeding Initiative; 2018. pp. 95–107.
34. Wooten SR. Losing ground: Gender relations, commercial horticulture and threats to local plant diversity in rural Mali. In: Howard PL, editor. *Women & plants: Gender relations in biodiversity management and conservation*. London and New York: Zed Books; 2003. pp. 229–40.
35. Christie ME, Van Houweling E, Zselezky L. Mapping gendered pest management knowledge, practices, and pesticide exposure pathways in Ghana and Mali. *Agric Hum Values*. 2015;32(4):761–75.
36. Schroeder RA. “Gone to Their Second Husbands”: Marital Metaphors and Conjugal Contracts in The Gambia’s Female Garden Sector. *Can J Afr Stud/Revue canadienne des études africaines*. 1996;30(1):69–87. <https://doi.org/10.1080/00083968.1996.10804408>

37. Linares OF. From past to future agricultural expertise in Africa: Jola women of Senegal expand market-gardening. *Proc Natl Acad Sci U S A*. 2009;106(50):21074–9. <https://doi.org/10.1073/pnas.0910773106> PMID: [19965372](https://pubmed.ncbi.nlm.nih.gov/19965372/)
38. Soumaoro T. Adaptations of market garden producers to climate change in southern Mali. *GeoJournal*. 2022;87(6):5413–24.
39. FAOSTAT. Statistical Division of the UN Food and Agriculture Organization. [cited 2023 Dec 27]. Available from: <http://faostat.fao.org/>
40. Bihon W, Ognakossan KE, Tignegre J-B, Hanson P, Ndiaye K, Srinivasan R. Evaluation of Different Tomato (*Solanum lycopersicum* L.) Entries and Varieties for Performance and Adaptation in Mali, West Africa. *Horticulturae*. 2022;8(7):579. <https://doi.org/10.3390/horticulturae8070579>
41. Dembélé S, Tignegre JB, Diarra BG. Development of the vegetable seed sector in Mali and opportunities for irrigated seed production. Shanhua, Taiwan: World Vegetable Center.
42. Pretty JN, Guijt I, Thompson J, Scoones I. *A Trainer's Guide for Participatory Action and Learning*. London: IIED; 1995. Available from: <http://pubs.iied.org/pdfs/6021IIED.pdf>
43. Fischer G, Wittich S, Fründt S. *Gender analysis in farming systems and action research: a training manual*. Ibadan, Nigeria: IITA; 2019. <https://cgspace.cgiar.org/handle/10568/100149>
44. INSTAT. *Enquête Démographique et de Santé au Mali 2018*. [Internet]. Bamako, Mali and Rockville, Maryland, USA: INSTAT, CPS/SS-DS-PF et ICF; 2019. Available from: <https://dhsprogram.com/pubs/pdf/FR358/FR358.pdf>
45. Sartas M, Schut M, Proietti C, Thiele G, Leeuwis C. Scaling Readiness: Science and practice of an approach to enhance impact of research for development. *Agric Syst*. 2020;183:102874. <https://doi.org/10.1016/j.agsy.2020.102874>
46. Stiem-Bhatia L, Koudougou S. Innovations for women's access to land. *Rural 21*. 2018;52(3):19–21.
47. Panfil Y, Robustelli T. *A Decade in the Making: The Evolution of Mobile Applications to Secure Tenure (MAST)* [Internet]. USAID Land; 2022. Available from: <https://www.land-links.org/document/a-decade-in-the-making-the-evolution-of-mobile-applications-to-secure-tenure-mast/>
48. Verploegen E, Mogannam L. *Clay Pot Cooler Training in Mali: Impact Study* [Internet]. MIT D-Lab, Tufts University, Institut d'Economie Rurale, and World Vegetable Center. [cited 2025 Mar 3]. Available from: <https://d-lab.mit.edu/resources/publications/clay-pot-cooler-training-mali-impact-study>
49. Turrittin J. Men, Women, and Market Trade in Rural Mali, West Africa. *Can J Afr Stud/Revue canadienne des études africaines*. 1988;22(3):583–604.
50. Baden S. Women's collective action in African agricultural markets: the limits of current development practice for rural women's empowerment. *Gender Dev*. 2013;21(2):295–311. <https://doi.org/10.1080/13552074.2013.802882>
51. Simard P. Assessing autonomy among Sahelian women: an analytical framework for women's production work. *Dev Pract*. 1998;8(2):186–202. <https://doi.org/10.1080/09614529853800> PMID: [12293702](https://pubmed.ncbi.nlm.nih.gov/12293702/)
52. Bellwood-Howard I. Donkeys and bicycles: capital interactions facilitating timely compost application in Northern Ghana. *Int J Agric Sustain*. 2012;10(4):315–27. <https://doi.org/10.1080/14735903.2012.666030>
53. Mayoux L, Oxfam Novib. *Rocky Road to Diamond Dreams: GALs Phase 1 – Visioning and Catalysing a Gender Justice Movement*. [Internet]. WEMAN Programme, Oxfam Novib; 2014. Report No.: Implementation Manual v.1.0. Available from: [https://www.oxfamnovib.nl/redactie/Downloads/English/SPEF/140701\\_RRDD\\_manual\\_July\\_small\(1\).pdf](https://www.oxfamnovib.nl/redactie/Downloads/English/SPEF/140701_RRDD_manual_July_small(1).pdf)
54. Diarra FB, Ouédraogo M, Zougmore RB, Partey ST, Houessionon P, Mensah A. Are perception and adaptation to climate variability and change of cowpea growers in Mali gender differentiated?. *Environ Dev Sustain*. 2021;23(9):13854–70. <https://doi.org/10.1007/s10668-020-00873-5>
55. Tamò M. Farmers in Africa should switch to biopesticides [Internet]. *SciDev.Net*. 2012 [cited 2023 Jan 13]. Available from: <https://www.scidev.net/global/opinions/farmers-in-africa-should-switch-to-biopesticides-1/>
56. Kawarazuka N, Damtew E, Mayanja S, Okonya J, Rietveld AM, Slavchevska V, et al. Considering gender in pest and disease management: FAQs for gender-responsive data collection and extension work (Vietnamese). 2020 [cited 2023 Jan 13]. Available from: <https://cgspace.cgiar.org/handle/10568/109053>
57. SOCODEVI. *Dou Touloma: Femmes, piliers de la famille* [Internet]. SOCODEVI. 2022 [cited 2023 Feb 10]. Available from: <https://socodevi.org/dou-touloma-femmes-piliers-de-la-famille/>