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Effects of Avocado Farming on Livelihoods and Biodiversity: Perspectives of Smallholder Farmers in Hai and Rungwe Districts, Tanzania

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Abstract

Agriculture production has long been regarded as an important sector for social and economic progress in most developing countries. However, it is also increasingly viewed as posing threats to biodiversity and the environment at large, hence the need for striking a balance between the two goals (economic progress and biodiversity conservation) through the adoption of environmentally friendly and healthy farming practices. In this paper, we use the case of avocado production in the Hai and Rungwe districts of Tanzania to investigate the opinions of smallholder farmers about the effects of avocado production on livelihoods and biodiversity. Specifically, we use the Likert's scale method to analyse and compare the opinions. The study findings show that smallholder producers had positive perceptions about the effects of avocado production on livelihoods and biodiversity. They viewed avocado farming as the most profitable business compared to other agricultural commodities. The effects of avocado on livelihoods were highly rated ranging from the lowest mean rank of 4.008 for the livelihood and market supports, to the highest of 4.3271, out of 5, for the livelihood protection threshold indicators. There were significant inter-district differences in opinions about the effects of avocado farming on biodiversity, especially for "water" (p = 0.002) and "fauna" indicators (p = 0.001) in which the Rungwe district registered relatively larger values than the Hai district. The paper underscores the need for the government and other development partners to support smallholder farmers so that they are enabled to produce high-value, and environmentally friendly avocados for the export market.

Keywords

Avocado Production, Exportation, Smallholder Livelihoods, Biodiversity Conservation, Perceptions

1. Introduction

In the 21st century, sub-Saharan African countries are experiencing investment and development in the agriculture sector (Gibbon, 2011; Baglioni & Gibbon, 2013; Coulson, 2015; Scoones et al., 2018). This is expected to be important in improving smallholder farmers' income and livelihood (Djokoto, 2012; Fuglie & Wang, 2012; FAO, 2012; Arshad, 2022). In addition, there have emerged new cash crops, including horticultural products such as fruits, vegetables, and cut flowers that have taken the position of many conventional export crops such as cotton, pyrethrum, sisal, and tobacco as the major export crops. One of these crops is avocado (*Persea americana*) (Repoa, 2018; URT, 2019; Achterbosch et al., 2014).

Tanzania is the third largest avocado producer in Africa, after South Africa and Kenya (TanzaniaInvest, 2023). For the first time, thousands of small-scale farmers in Tanzania started to produce and sell high-quality avocados to large European markets by 2010 (Feed the Future, 2015). This has mostly been facilitated by two fast-growing local private sector companies: Africado in West Kilimanjaro and Rungwe Avocado Company in the Mbeya region. The two companies dominate commercial production and export of avocados in Tanzania, jointly producing more than 5000 Tons per year (URT, 2019). The Tanzania Horticultural Association (TAHA) estimated that the country's avocado exports reached 11,237 tonnes or 510 containers worth USD 33 million in 2021 (TanzaniaInvest, 2023). In 2018, Tanzania exported 7551 tons to Europe, Africa, and Asia with a total value of about USD 8.6 million (URT, 2019; TanzaniaInvest, 2023). It was projected that Tanzania would export 15,000 tonnes of avocado in 2023 and generate USD 45 million in foreign currency (TanzaniaInvest, 2023).

Thus, avocado production has become an important part of livelihood diversification in producing regions in the country. It is important to note that livelihood diversification significantly promotes economic growth and reduces rural poverty, most especially in developing countries (Kadigi, 2022; Kadigi et al., 2022; Loison, 2019; Loison & Bignebat, 2017; Simtowe, 2010; Ellis, 1998). Thus, diversification is crucial for expanding the livelihood portfolios of smallholder farmers and raising rural incomes hence improving the living standards of the rural poor (Martin & Lorenzen, 2016; Pritchard et al., 2019). It is also a risk-reducing strategy enabling smallholder farmers to cope with economic fluctuation and environmental shocks (Reardon et al., 2007; Khatun & Roy, 2012; Rahut & Micevska Scharf, 2012; Himanshu et al., 2013; Gautam & Ander-

sen, 2016; Baird & Hartter, 2017; Asfaw et al., 2019; Gecho, 2017).

As much as a population close to 70% of the Tanzanian economy still depends on smallholder agriculture as their main source of livelihood, diversification within the farm and non-farm sectors remains crucial (Juma et al., 2019; URT, 2021). Its importance is even increasing now understanding that extensive agriculture is viewed as posing threats to biodiversity conservation and the environment at large (Klein et al., 2011; Ceballos et al., 2015; Ceballos et al., 2017; Cowie et al., 2022). This calls for the need to strike a balance between the two goals of economic progress and biodiversity conservation, through the adoption of environmentally friendly and healthy farming practices. Recognising this, the United Republic of Tanzania was among the countries that signed the United Nations Framework Convention on Climate Change (UNFCCC) (UNFCCC, 1996) as well as the Convention on Biological Diversity (CBD). The country signed the UNFCCC on 12 June 1992 and ratified it on 17 April 1996 and the Convention entered into force on 16 July 1996 (UNFCCC, 1996).

CBD is a multilateral treaty that aims to promote the conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of benefits arising from genetic resources. It was adopted on 22 May 1992 and entered into force on 29 December 1993. Tanzania ratified the CBD in 1996 and the Vice President's Office, Division of Environment is the National Focal Point for the Convention (URT, 2023).

Despite avocado production being increasingly adopted as a new export crop, empirical evidence on its effects on biodiversity and the livelihoods of farmers is lacking, at least in the context of smallholder farming in Tanzania. Most important is perhaps the understanding of these effects from the lenses of smallholder farmers themselves. In this paper, we use the case of avocado production in the Hai and Rungwe Districts of Tanzania to investigate the perceptions of smallholder farmers about the effects of avocado production on livelihood and biodiversity.

2. Literature Review

2.1. Definitions and Indicators of Livelihood

In agrarian societies, the concept of "livelihood" is associated first and foremost with people (FAO, n.d.), smallholder farmers in this context, and the goal is to achieve what is dubbed "sustainable livelihood" which is in turn a function of sustainable agrobiodiversity management (*ibid*). This has further resulted in the framing of the terms "Sustainable Livelihood Framework (SLF)" and "livelihood perspective" (*ibid*).

FAO (1999) defined "agrobiodiversity" as the variety and variability of animals, plants, and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry, and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel, and pharmaceuticals. It also includes the diversity of

non-harvested species that support production (soil micro-organisms, predators, pollinators), and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest, and aquatic) as well as the diversity of the agro-ecosystems.

According to DFID (1999), SLF presents the main factors affecting people's livelihoods and typical relationships between these and it cannot only be used as a framework for analysing sustainable livelihood, but also for facilitating the planning of new development activities (Morse & McNamara, 2013). The framework provides a checklist of important issues and sketches out the way these link to each other; draws attention to core influences and processes; and emphasizes the multiple interactions between the various factors affecting livelihoods (FAO, n.d.). According to Chambers and Conway (1992), livelihood comprises the capabilities, assets (including both material and social resources), and activities required for living. A livelihood is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future while not undermining the natural resource base (FAO, n.d.).

The "livelihoods perspective" maintains that the people themselves must be the main entry point for analysing livelihoods (Kollmair & Gamper, 2002) and agrobiodiversity management (FAO, n.d.). The "livelihood perspective" is holistic in terms of understanding the purposes and functions played by agrobiodiversity in livelihood strategies, and it is dynamic in terms of changing the priorities and needs of different people at different times (Kollmair & Gamper, 2002). The "livelihood perspective" builds on people's strengths, e.g. local knowledge for species selection and in situ conservation practices, and "sustainability" is important because the aim is to improve the capacities of farmers and empower them (FAO, n.d.).

The dimensions of sustainability include environmental; economic, social, and institutional aspects (DESA/DSD, 2001). The environmental dimension is achieved when the productivity of life-supporting natural resources is conserved or improved for the use of future generations; the economic dimension in the context of the livelihoods of the poor is achieved if a level of economic welfare is reached and maintained; the social dimension is achieved when social exclusion is mitigated and social equity is maximized; and finally the institutional dimension is achieved when present structures and processes have the capacity to continue performing their functions over the long term (DESA/DSD, 2001). SLF can be briefly described as a combination of resources, assets, or types of capital that result in a combination of livelihood strategies in order to achieve the desired livelihood outcomes in a specific context of vulnerability (Knutsson & Ostwald, 2006).

It is important to briefly review the dimensions of livelihood indicators here. Of relevance to our study are the livelihood indicators identified by the International Federation of Red Cross and Crescent Societies, IFRC (2016), for example,

identified twenty-two livelihood indicators, including among others the following:

1) Food security and nutrition;
2) Scope of survival and/or livelihood protection thresholds;
3) Ownership of, and access to, production assets;
4) Enhancement of productivity;
5) Increase and diversification of sources of income;
6) Acquisition and application of knowledge related to livelihood activities;
7) Access to livelihood-support services and markets;
8) Risk reduction and natural resources management; and
9) Improvement of policies, regulations, and rights for livelihood development (IFRC, 2016).

In our study, we used some of these indicators together with IFRC livelihood programming framework (**Figure 1**), and the indicators of livelihood to analyse the perceptions of smallholder farmers in the study areas on the effects of avocado production on livelihoods and biodiversity.

2.2. Biodiversity as a Bioindicator

The term "biodiversity" or "biotic diversity" is defined differently by different

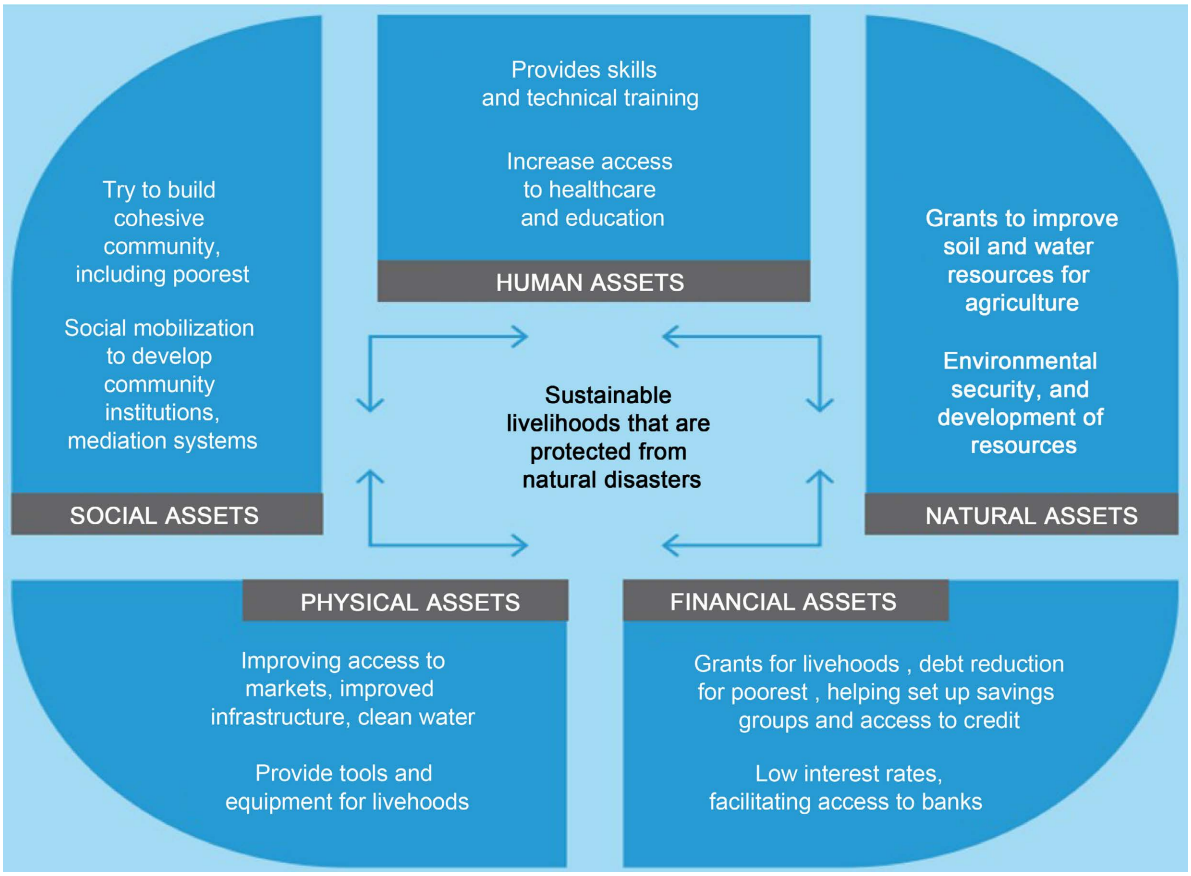

Figure 1. The IFRC livelihood programming framework to reinforce resilient to natural disasters. Sources: Solidalité International (2017) and IFRC (2010).

authors (Muralikrishna & Manickam, 2017). Muralikrishna & Manickam (2017), for example, define biological diversity (biodiversity) as "the occurrence of different types of ecosystems, different species of organisms with the whole range of their variants and genes adapted to different climates, and environments along with their interactions and processes." The two terms "biological diversity" and "biotic diversity" all refer to the idea of living variations, from genes and traits to species and to ecosystems which is the total of all biotic variation from the level of genes to the ecosystem (Stanford Encyclopedia of Philosophy, 2003).

It is further illustrated in the literature that the component of biodiversity can also be used as a bioindicator, which includes the shift in species (WHO, 2015). The bioindicator is predictable and often correlates highly with deposition measures and groups of organisms with high local biological diversity (e.g., insects and other arthropods) (WHO, 2015). In our study, we used this concept and contextualised it to suit the prevailing circumstances in the study areas.

2.3. The Theory of Perception

Like most concepts within the social science disciplines, perception (or what other scholars refer to as social perception) has been defined in a variety of ways since its first usage. Chambers Dictionary defines perception as an act of being aware of "one's environment through physical sensation, which denotes an individual's ability to understand." According to Nelson and Quick (1997), "social perception is the process of interpreting information about another person." This implies that the opinions one forms about another person depend on the amount of information available to him or her and the extent to which he or she is able to correctly interpret the information he/she has acquired.

Perception is the process whereby people select, organise, and interpret sensory stimulations into meaningful information about their work environment (Rao & Narayan, 1998). State differently, it refers to a process whereby people give the impression, judgment, opinion, and interpretation of something based on the information received through sensory stimulation. From sensory stimulation, it is then forwarded and processed into the brain (Michener et al., 2004). Thus perception has three elements such as selection, interpretation, and reaction. Selection is a stage of the screening process by the senses toward the external stimuli. Then proceed with organizing the information so that it will have meaning. Interpretation and perception are then translated into the form of behaviour as a reaction.

Perception is formed through the process of combining and interpreting which is then manifested in the form of judgment (Michener et al., 2004), and is affected by both internal and external factors. The internal factors could be influenced by some aspects, such as:

1) Attitude or a process of assessment of an object that is shown in the form of a reaction: can be defined as the individual positive or negative feelings about the performing behaviour or condition (Ajzen & Fishbein, 1980). Psychological-

ly attitude is defined as an individual's response toward a particular topic (Ashaari et al., 2011; Chiesi & Primi, 2009; Hannula et al., 2016; Jahan et al., 2016). The depth of one's attitude toward an object can be measured through his/her knowledge, feelings, and how he/she treats the object.

2) Needs and wants: everyone has different levels of needs and wants. Expectations, motivation, and desires of people also influence people's perception of others and situations around them (Rao & Narayan, 1998).

3) Experience: could be gained from events one has ever faced. Someone perceives something is not only determined by the stimulus objectively but could also be determined by experience.

4) Personality: individual characteristic behaviour is another influence on what people's opinion about something.

External factors could be influenced by some aspects, such as:

1) Intensity: the things that could be understood which will be more if the intensity of stimulus from outside is greater.

2) Size: if the size of an object is larger, it is easier to be known or understood. This form of size will affect a person's perception.

3) Repetition: repetition will increase our sensitivity or alertness to the stimulus. Repetition is an external attraction to an object that could affect a person's perception.

4) Movement: people will give more attention to moving objects rather than silent objects.

According to Nelson and Quick (1997), there are three major characteristics that influence our perception of other people:

1) Perceivers-Specific Characteristics: One of the perceivers-specific factors that influence perception is familiarity with the object of perception. Another factor that influences social perception is the perceiver's attitude. Our mood is another important factor that affects the way we perceive others. People tend to more easily remember information that identifies with their moods than those that do not. Accordingly, whenever they are in negative moods they generally tend to form negative impressions of others. The self-concept of the perceiver is also a critical determinant of perception. Basically, people that possess positive self-concepts tend to perceive positive attributes in other people, while, those with negative self-concepts tend to perceive negative attributes in others.

2) Target-Specific Characteristics: Social perception is also influenced by certain characteristics that are specific to the person being perceived (i.e. the target).

3) Situation-Specific Characteristics: This is a very significant factor that affects the impression that is formed about someone by an individual. In other words, the Social context of the interaction is a major influence.

2.4. Empirical Review

The Likert scales and Likert-type methods as well as the t-test are widely used in the literature to rank perceptions or opinions and test the level of agreement and

the differences in perceptions among respondents. They are also extensively used in the analysis of factors influencing the selection of product outlets (e.g. the study by Kadigi, 2013) and the adoption of environmentally friendly production systems or technologies (Kadigi et al., 2021). Very often, these methods are complemented by the testing of agreement in opinions among respondents using the procedure described by Legendre (2005, 2010). In this regard, the Kendal coefficient of concordance, W, is extensively applied. According to (Legendre, 2005, 2010), Kendall's W ranges from 0 to 1, with the value of 0 meaning that there is no overall trend of agreement among the respondents. The value of 1 means perfect or complete agreement and the values in between indicate a greater or lesser degree of unanimity among the various respondents (Legendre, 2005, 2010).

Kadigi (2013) for example, conducted a study to investigate the factors influencing the choice of milk outlets among smallholder dairy farmers in Iringa Municipality and Tanga City. He used the t-test to find out if there was a statistical difference between the gross margin of formal and informal milk value chains. His research showed that the formal and informal milk value chains were not equally rewarding. In their study of the perceptions of smallholder farmers on nature-based income generating activities as potential livelihood and biodiversity conservation strategies in Uluguru Mountains, Tanzania, Kadigi et al. (2021) used Kendall's Coefficient of Concordance, W, to test the hypotheses that the smallholder farmers in the study area did not agree among themselves about the ranking of potential livelihood and biodiversity-enhancing nature-based income generating activities (NIGAs), and that the promotion of agroforestry has reduced the communities' reliance on firewood, building poles and wood from the Uluguru Forest Reserve (UFR).

In our study, the assessment of the effects of avocado farming on livelihoods and biodiversity was centric for two main reasons. Firstly it was a "livelihoods perspective" centred assessment that considered the people (i.e. the smallholder farmers themselves) as an important part of the research team due to their experience in avocado farming. Secondly, the focus of perception analysis was based on the twin objectives of achieving both economic sustainability and environmental (biodiversity) sustainability which requires making difficult trade-off decisions. Such an analysis seems to be lacking in the literature. Most of the previous studies on avocado farming in East Africa, for example, have focused on the factors influencing the adoption of commercial avocado farming and access to new export markets. Some studies on the dynamics and role of gender in high-value avocado farming also exist.

A few examples are worth mentioning here. The study by Johnny et al. (2019) in Kenya for example, investigated the factors determining the involvement of smallholder farmers in avocado contract farming and decomposed those contributing to differentials in quality and quantities of fruit harvested and sold by contract and non-contract farmers. The findings from the probit analysis showed

that the adoption of Hass and Fuerte varieties, hired labour, and information on production and marketing significantly influenced participation in contract farming. The results from gap analysis using the Oaxaca-Blinder decomposition method suggested that the quality and quantities of avocados harvested and sold differed between contract and non-contract farmers. These differences were caused by endowment and structural differences. They conclude that closing the observed gap would require policies targeted at facilitating better access to land and training farmers in good agricultural practices among other support services.

Muriithi & Kabubo-Mariara (2022) used two-wave panel data obtained from avocado growers in Murang'a County in Kenya to examine, through the perspective of gender, the dynamics of farmers' participation in avocado production and marketing organizations, and test whether understanding group dynamics was important for analyzing contract farming. Their results revealed heterogeneity with regard to household, farm, and resource characteristics across categories of farmers and between gender groups. They also revealed that group and contracting dynamics were related and recommended policy efforts to focus on supporting women farmers to enhance their participation in avocado production and marketing organisations (PMOs) PMOs, which ultimately affects contracting. Muriithi & Kabubo-Mariara (2022) also underscore the need to improve access to high-yielding avocado varieties and build capacity in orchard management that would enhance women's decision-making including group participation, contracting, and marketing. In addition, they recommend the provision of low-cost agricultural credit that would also improve women's ownership of improved avocado trees and hence their participation in high-value markets.

In the southern highlands of Tanzania, Juma et al. (2019) investigated avocado as an emerging trade commodity from horticulture. Specifically, they explored the yield and performance of the value chain of this crop in the study area based on data gathered using face-to-face interviews with different actors including 275 avocado farmers, 231 avocado traders, and 16 key informants (*ibid*). Juma et al. (2019) employed the Chi-square test and one-way analysis of variance methods to pinpoint the challenges that hindered the development of the avocado industry in the study area. Poor quality of avocado produce, high transaction costs, limited access to extension support services, lack of working facilities, limited financial support to extension officers, as well as unfavourable climatic conditions constituted some of the key challenges that affected profitability along the avocado value chain in the study area (Juma et al., 2019).

2.5. Methodology

2.5.1. Data Collection, Sampling Procedure, and Sample Size

This paper is based on data gathered from a sample of 120 smallholder farmers who produced avocados for exportation in Tanzania. The study applied a mul-

tistage sampling method comprising four main stages. The first stage entailed the purposeful sampling of two regions in the country that produced Hass avocado for exportation (i.e. Kilimanjaro and Mbeya). The second stage involved the selection of districts (one district from each region) which were selected using three main criteria namely the quantity of Hass avocado produced; the number of out-growers engaged in the production of the crop; and the existence of companies that buy Hass avocado from out-growers and export it overseas. The third stage entailed a random selection of sample wards based on their importance in producing avocados for exports (Hass avocado). The fourth and last stage involved randomly selecting smallholder avocado producers in selected wards (three wards in Hai district, and four wards in Rungwe district were chosen).

The determination of sample size (S) in this study took into consideration all the important factors including time available for the accomplishment of the study. In total 120 smallholder farmers were selected, including 48 and 72 in Hai and Rungwe districts respectively. These sample sizes were considered adequate to make reasonable statistical inferences for the research study (Altunışık et al. 2004).

The primary data were collected through interviews using a semi-structured questionnaire administered to all selected avocado producers with the help of the Android application GeoODK.

2.5.2. Development of the Data Collection Tool

The questionnaires constituted both open and closed questions on avocado producers' perceptions regarding the production of avocado on livelihood and biodiversity. In particular, we used the Likert scales and Likert-type questions, to collate information and measure the perceptions of smallholder farmers following the procedure described by Clark et al. (1998). We used a scale of five values starting from 1 to 5 for scoring the individual statements presented in **Table 1** and **Table 2**. Accordingly, 3 was the median score and neutral option; any scores below 3 indicated negative values (i.e. the respondents disagreed with the statement), while scores above 3 indicated positive values (i.e. the respondents agreed with the statement). Stated differently, we used a Likert-scale and Likert-type with a five-point continuum starting from 1 (strongly disagree) to 5 (strongly agree) to form a single composite variable (Clason & Dormody, 1994) and categorised respondents into two groups using a cut-off point of 2 (that is, did not perceive, if the score was less than 3, and, perceived, if the score was equal to or greater than 4).

The perception and attitude scales (later named Likert scales) were introduced by Rensis Likert in June 1932, with their work on "a technique for the measurement of attitudes" (Likert, 1932). Often these perceptions and attitudes are conceived as clustered so that a group factor is assumed at the outset (Likert, 1932). This is the reason why Likert scales are defined as multi-Likert item scales

Table 1. Set of livelihood variables, indicators, and statements used in perception analysis.

Code	Indicator	Variable	Statement or variable description
1	Livelihood protection threshold	Survival	There has been a positive change in household capacity to meet their survival threshold resulting from growing avocado (which is a perennial crop) compared to annual crop farming
		Protection	There has been a positive change in the capacity of households to meet their livelihood protection threshold due to improved earnings from avocado production
		Restore	There has been a substantial improvement in the restoration of livelihoods compared with the conventional crop production
		Coping strategies	There has been a positive change in households' coping strategies following the engagement in the production of avocado for export
2	Ownership and access to productive asset	Improvement in asset quality	There has been a positive change in the quality of productive assets owned or accessed by farmers, following earning more income from avocado production
		Ownership of, and access to productive assets	There has been an increase in ownership and access to productive assets as a result of earning more money from avocado production
		Ability to recover lost assets	There has been a significant improvement in the ability of smallholder farmers to recover the lost livelihood productive assets and infrastructure as a result of earning more income from avocado production
3	Productivity enhancement	Improved productivity	There has been a positive change in farm productivity following the adoption of avocado production for export market
		Reduced production loss	There has been a positive change in production losses due to improved avocado farming systems
4	Diversification of income	Increased net income	There has been a positive change in the net income following the engagement in avocado production for export market
		Diversified income	Sources of income have diversified more as a result of engagement in avocado production for the export market
		Employment	There has been a positive change in the number of people employed or self-employed in both farm and non-farm sectors
		Strengthened entrepreneurship	There has been a positive change in smallholder farmers' entrepreneurship capacity
5	Gaining and applying new knowledge and skills	Gaining new knowledge and skills	The number of people equipped with new knowledge and skills that were introduced by avocado exporting companies has increased
		Applying new knowledge and skills	The number of people applying new knowledge and skills introduced by avocado exporting companies has increased

Continued

6	Livelihood support services and market	Number of supporting institutions	There has been a positive change in the number of organisations, and MSMEs (Micro, Small & Medium Enterprises) supporting access to livelihood services and profitable markets for avocado farmers
		Quality of support	There has been a positive change in the quality of livelihood support services and market-related initiatives
7	Disaster risk reduction and management	Number of sustainable livelihood activities	The number of households, communities, organisations, and MSMEs applying or supporting sustainable livelihood practices to enhance the capacity of farmers to manage NRs and reduce risks has increased substantially
		Number of NRUIM	The number of Natural Resources Under Improved Management (NRUIM) following the engagement of smallholder farmers in the production of avocados for export
		Number and value of productive assets	The number and value of productive assets (e.g. lands, livestock, infrastructures) that enhance the capacity of farmers to cope with natural or human disasters or threats has increased

Table 2. Set of biodiversity variables, indicators, and statements used in the perception study.

Code	Variable	Statement or variable description
1	Fertility	Shift from the production of annual crops to avocado (a perennial crop) has helped to control soil erosion and has improved soil structure and fertility, increased ecosystem nutrient retention, carbon sequestration, and water infiltration, and it has therefore helped to conserve soil organisms or biodiversity
2	Water	Avocado, like many other perennials, plays an important ecosystem function of enhancing soil water retention as well as moisture infiltration and storage, creating a favourable microclimate buffer zone for soil organisms
3	Flora	By enhancing soil fertility, water retention, and infiltration avocado trees improve ecosystem health and support a number of understory vegetation and soil flora
4	Fauna	Avocado trees support many fauna species that live in soils, on trees, and in the understory vegetation including insects, bees, beetles, butterflies, birds, lizards, tree frogs, and others
5	Education and public awareness on biodiversity	The "Communication, Education and Public Awareness" (CEPA) programmes introduced by avocado exporting companies operating in the study areas have helped to create awareness of biodiversity
6	Habitat protection	Avocado trees have increased habitat niches for biodiversity
7	Environment	By reducing soil erosion and enhancing soil organic matter and carbon sequestration, avocado trees have helped to conserve the environment and decrease environmental pollution

(Guerra et al., 2016).

In fact, Likert-type items are similar to Likert items but do not respect some of

their characteristics (Guerra et al., 2016). Clason and Dormody (1994) compare Likert scales to Likert-type items. For them, the difference between Likert scales and Likert-type items is that the former contains Likert items as single questions that use some aspect of the original Likert response alternatives but do not cluster them into composite scales (Guerra et al., 2016). Thus, several items always compose a Likert scale: it is never an individual Likert item (*ibid*). More precisely, a Likert scale is a scale composed only of Likert items and the Likert-type items only compose a Likert-type scale (Guerra et al., 2016).

2.5.3. Testing of Agreement in Opinions

In this paper, we use Kendall's coefficient of concordance (W) to test agreement between respondents (Kendall & Babington-Smith, 1939) which is similar to Spearman's rank correlation coefficient1 (Spearman, 1904). The test is used when appropriate measures of intra-group similarity in the case of multivariate analyses are missing. According to Marcinkiewicz (2017) and Elzinga et al. (2011), the idea of concordance appears in at least three contexts: in voting and decision-making, which is the first and primary application of the idea, in group perception or attitude assessment, and in statistics. The general index of concordance can be expressed as in Equation (1) (Legendre, 2010, 2005).

$$W = \frac{12S}{m^2\left(n^3 - n\right) - mT} \tag{1}$$

where; W is Kendal's coefficient of concordance, m represents the quantitative or semi-quantitative variables, n is the number of objects of interest, S represents thesum-of-squares statistic over the row sums – calculated as in Equation (2) (Legendre, 2010, 2005), R_k represents the row ranks, and R_m is the mean of the R_k.

$$S = \sum_{k=1}^{n}\left(R_k - R_m\right)^2 \tag{2}$$

3. Results and Discussion

3.1. Major Sources of Income in the Study Areas

Although the major source of income for smallholder farmers in the study areas, as for many other rural communities is agriculture, many smallholder families also earn income from non-farm sources. The respondents were asked to rank all the economic activities that they were engaged in as their sources of income and the results are presented in **Table 3**. Avocado production was leading with a mean rank of 2.12, followed by monthly salaries and wages (mean rank of 3.75) and other horticulture produce (mean rank of 4.13). Beekeeping and irregular casual labour work ranked last with mean ranks of 9.05 and 8.84 respectively. These ranks support the proposition that avocado is emerging as a main export produce and an important source of income for smallholder farmers in Tanzania (Juma et al., 2019).

These results also support the assertion that the growing of other horticultural

Table 3. Results of ranking of the sources of household income in the study areas (n = 120).

Code	Source of income	StDev	Minimum	Maximum	Mean Rank
1	Avocado	1.124	1.00	5.00	2.12
2	Other horticulture produce	1.742	1.00	8.00	4.13
3	Cereal and Legumes	1.865	1.00	10.00	5.56
4	Livestock keeping	2.236	1.00	8.00	5.32
5	Beekeeping	1.095	5.00	10.00	9.05
6	Poultry production	2.043	1.00	10.00	5.76
7	Pig production	2.151	1.00	10.00	5.62
8	Monthly salaries and wages	2.906	1.00	9.00	3.75
9	Business	2.765	1.00	9.00	4.85
10	Casual labour work	1.863	1.00	10.00	8.84

Kendal's $W = 0.493$ $x^2 = 532.837$ ($P = 4.17E{-}109$) n = 120; where x^2 is Chi-square.

produce, such as vegetables, is very important to the rural farmers' income, and plays a significant role in their households' economic status (Nanjala, 2023; Schreinemachers et al., 2017). It serves as a significant source of income for farmers and helps them with the cash needed for their daily household needs (*ibid*).

When the data distribution is normal or approximately normal it is important to measure variability among them (Lee et al., 2015). One of the simplest ways to do that is to look at the standard deviation which refers to the average amount by which scores differ from the mean. It is the square root of the variance (Curran-Everett et al., 1998). State differently, the standard deviation measures how dispersed the data is in relation to the mean (Altman & Bland, 2005). Low, or small, standard deviation indicates data are clustered tightly around the mean, and high, or large, standard deviation indicates data are more spread out (Lee et al., 2015; Curran-Everett & Benos, 2007).

The standard deviation for avocados was the smallest (i.e. 1.124), followed by other horticultural produce and casual labour work, with standard deviations of 1.742, and 1.863 respectively. Moreover, monthly salaries and wages constituted the most spread out source of income with a standard deviation of 2.906, meaning that there were fewer respondents who relied on monthly salary and wages as their primary source of income.

The results of analysis of the Kendall's W test, show a point estimate of the coefficient of concordance of 0.493 which was moderate because it was within the range of $0.3 < W < 0.6$ (Gearhart et al., 2013). The respondents were therefore concordant in ranking all the ten income sources at the asymptotic p-value of 0.005 which strongly suggests that the coefficient of concordance was not zero. However, it is important to note that Kendall's W being not equal to 1 (which would literally mean that the respondents did not perfectly agree amongst themselves) does not imply that they did not rank the income sources in the

same order but each source faired well at the hands of some respondents and poorly at the hands of others (Kadigi et al., 2021). Under perfect disagreement, each income source would fare the same overall and would thereby produce identical values for equal total rankings for all income sources, consequently, Kendall's *W* would be equal to zero (*ibid*).

3.2. Perception of the Effects of Avocado Farming on Livelihoods

3.2.1. Effects on Livelihood Protection Threshold

In our study, we used the term "livelihoods protection threshold" to refer to the income required to sustain current livelihood activities and access to basic services as defined by IFRC (2016). We considered the households below this threshold as having eroded resilience and requiring assistance to protect their livelihoods (*ibid*). Specifically, we chose a set of four individual statements or variables to serve as indicators of likelihood protection that included: survival, protection, restoration, and coping strategies variables (see **Table 1** for the full description of the variables). Combining together the "strongly agree" and "agree" responses the results of the analysis in **Table 4** show that about 87% of the respondents perceived that avocado farming had positive effects on the households' capacity to meet their survival thresholds (i.e. the survival variable).

About 98% of all respondents also viewed that the production of avocados for exportation had resulted in positive effects on the households' capacity to meet their livelihood protection threshold. More than 90% also felt that avocado production has significantly contributed more to restoring their livelihoods compared with the conventional cropping systems (93.3%) and that it has substantially improved the quality of livelihood coping strategies among the smallholder farmers in the study areas (93.6%). For all four individual statements or variables, the mean ranks were greater than 4 ranging from the minimum of 4.2667 (for coping strategies) to the highest of (4.4583 for the survival variable). The composite mean rake was 4.3271 (StDev = 0.605) implying huge effects on the livelihood protection threshold.

Overall, these results suggest that avocado production for the export market in

Table 4. Descriptive statistics of the effects of avocado production on livelihood protection threshold.

Variables	SA	A	N	D	SD	Mean rank	StDev
Survival	71 (59.2)	33 (27.5)	16 (13.3)	0	0	4.4583	0.72060
Protection	37 (30.8)	80 (66.7)	3 (2.5)	0	0	4.2833	0.50516
Restoration	45 (37.5)	67 (55.8)	7 (5.8)	1 (0.8)	0	4.3000	0.61631
Coping strategies	40 (33.3)	72 (60)	8 (6.7)	0	0	4.2667	0.57589
Composite mean rank = 4.3271[†]							
Composite standard deviation = 0.605							

[†]Values in the brackets are per cents.

the study area is an important source of income that can help smallholder farmers to sustain their livelihoods. In this regard, sustainability means that the source is able to meet the total household's expenditure to ensure basic survival (i.e., all the items covered in the survival threshold), capable of maintaining access to basic services (e.g. health and education), sustaining livelihoods in the medium to longer term, and achieving a minimum locally acceptable standard of living (Holzmann et al., 2008).

3.2.2. Effects on Ownership and Access to Productive Assets

As for the livelihood protection threshold, the production of avocados for export markets was perceived to have resulted in significant positive effects on the ownership and access to productive assets (**Table 5**). The study findings indicate positive changes for all three individual indicators of asset quality (i.e. the quality of productive assets owned or accessed by farmers; ownership and access to productive assets; and ability to recover the lost livelihood productive assets and infrastructure. For each indicator, more than 90% of the respondents perceived avocado production as resulting in positive livelihood changes with a composed mean rank of 4.2472 (StDev = 0.517).

The relationship between ownership and rights over productive assets, such as land, housing, and livestock, and the quality of livelihood is widely studied in the literature (De la Vega-Rivera & Merino-Pérez, 2021; Tatwangire, 2011; Solotaroff et al., 2019; Ibrahim et al., 2018). In Mexico, the study by De la Vega-Rivera & Merino-Pérez (2021) showed that engagement in avocado production helped the communities to expand their land and retrieve their stolen lands. In the context of women rural farmers in Bangladesh, for example, Solotaroff et al. (2019) investigated ownership and control over productive assets. They found that ownership and rights over productive assets, such as land, housing, and livestock, remained closely related to economic empowerment and livelihoods of women. Rural women who had rights over productive assets tended to hold jobs, have access to financial services, and control income (*ibid*).

Table 5. Descriptive statistics of the effects of avocado production on ownership and access to productive assets.

Variable	SA	A	N	D	SD	Mean rank	StDev
Asset improvement	43 (35.8)	70 (58.3)	7 (5.8)	0	0	4.3000	0.57394
Ownership of, and access to productive assets	27 (22.5)	92 (76.7)	1 (0.8)	0	0	4.2167	0.43354
Ability to recover lost assets	34 (28.3)	79 (65.8)	7 (5.8)	0	0	4.2250	0.54174
Composite mean rank = 4.2472[†]							
Composite standard deviation = 0.517							

[†]Values in the brackets are per cents.

Elsewhere in Uganda, Tatwangire (2011) assessed the impact of access to productive assets on the welfare of rural farm households. He provided a shred of robust empirical evidence on the poverty-reducing impact of land access through market and non-market avenues in rural Uganda. He found significant poverty reduction effects of increased land access in the form of owned, operated and market-accessed land after controlling for the endogeneity bias of land access and welfare effects of the unobserved heterogeneity. Ibrahim et al. (2018) analysed the level of livelihood assets ownership among vulnerability groups in Kelantan, East Coast of Malaysia. Based on Sustainability Livelihood Analysis (SLA), they found that the human asset was the key asset that contributed to the livelihood compared to other assets of the vulnerability group in the study area.

3.2.3. Effects on Productivity

The effects of avocado production on overall farm productivity were measured using two indicators of improved farm productivity and reduced production losses. As shown in **Table 6**, avocado production positively influenced change in livelihoods with a composite mean rank of 4.2083 (StDev = 0.540). The results showed that almost all farmers perceived avocado farming as improving overall farm productivity (99.2%) and reducing production losses (86.7%). This can be attributed to many factors, including the adoption of good avocado farming practices, such as appropriate tree spacing and routine pruning, application of organic manure and mulching, and adhering to pest and disease control measures, just to mention a few.

The available evidence shows that in Qalqilya Governorate, Palestine, good agricultural practices through Farmer Field Schools (FFSs) contributed to improving avocado production and productivity (FAO, 2021a). In this area, FFSs were used as a way to enhance local farming techniques through targeted capacity development activities delivered in the form of on-the-job training to Palestinian farmers (*ibid*). The training was delivered to groups of 15 to 20 farmers and focused on imparting good agricultural practices related mainly to water usage, modern crop management methods, reduction of chemical pesticides, and

Table 6. Descriptive statistics of the effects of avocado production on farm productivity.

Variables	SA	A	N	D	SD	Mean rank	StDev
Improve production	41 (34.2)	78 (65)	1 (0.8)	0	0	4.3333	0.49081
Reduce production loss	26 (21.7)	78 (65)	16 (13.3)	0	0	4.0833	0.58817
Composite mean rank = 4.2083[†]							
Composite standard deviation = 0.540							

[†]Values in the brackets are percentages.

proper disease and pest control, resulting in decreased input costs and increased economic return and resilience of farmers, and enhanced water productivity per drop (*ibid*).

3.2.4. Effects on Diversification of Income Sources

As shown in Table 7, the respondents agreed to a great extent that avocado production positively influenced the diversification of income sources registering a composite mean rank of 4.1604 (StDev = 0.547). The mean ranks for individual variables of the effects of avocado production on diversification of income sources ranged from the lowest of 4.0417% or 88.4% of those who agreed that it has caused a change in entrepreneurship capacity, to the highest of 4.2833% or 95.8% for those who perceived that it has resulted in increased net income for smallholder farmers. The available evidence shows that avocado production and trade has enabled smallholder farmers to diversify their sources of income and gain greater income from these sources.

The role of avocado production and trade in the diversification of rural income is increasingly researched in the literature. In Tanzania, the study by REPOA (2018) investigated the opportunities and potential of avocado production with a special focus on the Northern Export Corridor. They discuss the key production, trade, and regulatory constraints undermining competitiveness and underscore the role of avocados in diversifying income sources. To address the existing constraints they recommend drastic changes in policy towards enhancing productivity and competitiveness, value chain upgrading, and export diversification as well as improving the standards and quality of the crops. REPOA (2018) also recommended that, as the Tanzanian avocado industry grows, there is a need for smart policy and capacity-building interventions and regulations to promote competitiveness and diversification of the subsector, create jobs, and generate wealth and economic development. In Giheta, Burundi, the study by Hakizimana & May (2018) showed that increasing the capacity of avocado production and trade enabled small-scale farmers and vendors to gain greater

Table 7. Descriptive statistics of the effects of avocado production on diversification of income.

Variables	SA	A	N	D	SD	Mean rank	StDev
Increased net income	39 (32.5)	76 (63.3)	5 (4.2)	0	0	4.2833	0.53740
Diversified income sources	30 (25)	85 (70.8)	4 (3.3)	1 (0.8)	0	4.2000	0.52820
Employment	27 (22.5)	80 (66.7)	13 (10.8)	0	0	4.1167	0.56781
Enhanced entrepreneurship	20 (16.7)	86 (71.7)	13 (10.8)	1 (0.8)	0	4.0417	0.55603
Composite mean rank = 4.1604[†]							
Composite standard deviation = 0.547							

[†]Values in the brackets are percentages.

income from this sector. They argue further that avocado production represented an opportunity to diversify the rural agricultural sector that, in developing countries, is often dominated by one or two traditional cash crops such as coffee or tea which are subjected to declining prices (*ibid*). Thus, from a policy perspective, Kakizimana & May (2018) recommended that the avocado sector should be supported by both the private and public sectors, irrespective of whether the crop is consumed, traded domestically, or exported.

In Tanzania, exporting countries are introducing and promoting avocado production as an alternative cash crop. A typical example in the country is the Africado that operates in Hai, Kilimanjaro region. Due to fluctuating prices in the global market, coffee returns have declined substantially in the region and Africado introduced avocado as an alternative cash crop to coffee (SPICA-ICV, 2023).

3.2.5. Effects on Gaining and Applying New Knowledge and Skills

As for the previous indicators, there were also positive effects of avocado production on equipping farmers with and enabling them to apply, new knowledge and skills introduced by the avocado exporting companies in their areas (**Table 8**). The results of perception analysis yielded a composite mean rank of 4.0917 (StDev = 0.555), and a mean rank for each of the two individual variables (i.e. "gaining new knowledge and skills" and "applying new knowledge and skills") of 4.0917 with standard deviations of 0.50203 and 0.60801 respectively. The proportions of respondents who perceived that avocado production has enabled smallholder farmers to gain new knowledge and skills and apply them were 92% and 86% for the two individual variables respectively.

These findings are not surprising understanding that the avocado exporting companies in Tanzania have initiated several training programmes in their area of operation (SPICA-ICV, 2023). The Achmea's HR Business Partner Jacomina Baatje in Sanya Juu, Kilimanjaro, Tanzania, for example, conducted Leadership Training at Africado Ltd. in May 2019 (SPICA-ICV, 2023). Through the Train-the-Trainer Programme which was designed by Africado for "farmer-trainers" about

Table 8. Descriptive statistics of the effects of avocado production on gaining and applying new knowledge and skills.

Variables	SA	A	N	D	SD	Mean rank	StDev
Gaining new knowledge and skills	21 (17.5)	89 (74.2)	10 (8.3)	0	0	4.0917	0.50203
Applying new knowledge and skills	28 (23.3)	75 (62.5)	17 (14.2)	0	0	4.0917	0.60801
Composite mean rank = 4.0917[†]							
Composite standard deviation = 0.555							

[†]Values in the brackets are percentages.

2000 farmers were trained and supported by the company (SPICA-ICV, 2023). It should also be noted here that the company does not only provide training to farmers but it also finds export markets for avocados and creates the opportunity for them to generate a reliable source of income (SPICA-ICV, 2023).

Similarly, the Rungwe Avocado Company (RAC) in the Mbeya region, has supported 4300 outgrowers through the provision of seedlings, training, and extension services simultaneously increasing their income while also promoting conservation through conservation covenants (RAC, 2019). The outgrowers conservation covenants restrict engagement by farmers in poverty-related activities like poaching and unsustainable natural resource extraction (*ibid*). Through this partnership, the farmers have a secure market from which they get a fair price for their produce (*ibid*).

3.2.6. Effects on Access to Livelihood Support Services and Markets

The results of the opinion ranking regarding the effects of avocado production on access to livelihood support services and lucrative or profitable markets (**Table 9**) indicate a large composite mean rank of 4.0083 (StDev = 0.565). The mean ranks for the individual variables of access to livelihood and market support services were also large: equal to 4.0160 (StDev = 0.579530) for the number of livelihood and market supporting institutions, as perceived by about 88% of the respondents, and equal to 4.0000 (StDev = 0.55002) for the quality of supports, as perceived by 87% of all the respondents.

The problem of limited access to livelihood support services and rewarding markets for smallholder avocado farmers is often mentioned in the literature as one of the key factors hindering the development of the industry in developing countries. As a result, smallholder producers in these countries are often unable to integrate into markets and access high-value opportunities by effectively participating in global chains for high-value fresh produce. In Tanzania, the recent study by Malekela (2022) confirms the persistence of this problem. The study established that actors along the value chain of avocados, especially smallholder farmers and traders experienced low prices, unreliable markets, damaging avocados, poor transport systems, lack of market information, as well as the lack of capital and low fruit quality (*ibid*). Intrinsically, the study recommended that the

Table 9. Descriptive statistics of access to livelihood support services and markets.

Variables	SA	A	N	D	SD	Mean rank	StDev
Number of supporting institutions	19 (15.8)	86 (71.7)	13 (10.8)	2 (1.2)	0	4.0167	0.57953
Quality of support	17 (14.2)	87 (72.5)	15 (12.5)	1 (0.8)	0	4	0.55002
Composite mean rank = 4.0083[†]							
Composite standard deviation = 0.565							

[†]Values in the brackets are percentages.

government should help farmers to identify reliable markets for the crop (*ibid*). However, the smallholder farmers who work with exporting companies such as Africado and RAC in Tanzania seem to be relatively better off in this regard.

In Kenya, Amare et al. (2019) examined the determinants and impacts of smallholder-producer participation in avocado export markets. They found that farmers who participated in export markets differed significantly from non-participating farmers: they had relatively larger farms, had received more training, and owned more avocado trees of the Hass variety, the type of avocado favoured in export markets. In addition, they associated residing close to a well-functioning avocado farmers' group with participation in export markets (*ibid*). More importantly, their findings show that although participation in avocado export markets had positive impacts on incomes, revenues, prices, and labour inputs, there was an offsetting effect in terms of higher prices and lower volumes, reflecting the stringent quality requirements of export markets (*ibid*). They recommended that policymakers should not only focus on resource accumulation for farmers, but they should also pay attention to the inclusiveness of smallholder farmers in the export markets (*ibid*).

3.2.7. Effects on Disaster Risk Reduction and Management

Based on this ground we also asked the respondents to indicate their opinions on whether avocado production by smallholder farmers in the study areas has contributed to disaster risk reduction and management. Disaster risk management is defined by the United Nations Office for Disaster Risk Reduction (UNDRR) as "the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses" (UNDRR, n.d.). For this indicator, we included three individual variables: the number of households, communities, organisations, and MSMEs applying or supporting sustainable livelihood practices to enhance capacity to manage NRs and reduce risks, the number of Natural Resources Under Improved Management (NRUIM), and the number and value of productive assets that enhance the capacity of farmers to cope with natural or human disasters or threats. The results of perception analysis are summarised in **Table 10**.

Overall, the composite mean rank was 4.1833 (StDev = 0.531) indicating a high rank. The mean ranks for individual variables ranged from the lowest of 4.1583 (StDev = 0.50203) for the number of sustainable livelihood activities variable to the highest of 4.2583 (StDev = 0.54226) for the number and value of productive assets. The proportions of those who perceived that the number was increasing for all the three individual variables of disaster risk reduction and management were approximately the same (93%) for the number of sustainable livelihood activities, and the number of NRUIM, and about 97% for the number of productive assets.

Understanding that avocado farming, like any other crop growing, largely

Table 10. Descriptive statistics of the effects of avocado production on disaster risk reduction and management.

Variables	SA	A	N	D	SD	Mean rank	StDev
Number of sustainable livelihood activities	26 (21.7)	87 (72.5)	7 (5.8)	0	0	4.1583	0.50203
Number of NRUIM	26 (21.7)	85 (70.8)	8 (6.7)	0	0	4.1333	0.54900
Number and value of productive assets	36 (30)	80 (66.7)	3 (2.5)	1 (0.8)	0	4.2583	0.54226
Composite mean rank = 4.1833[†]							
Composite standard deviation = 0.531							

[†]Values in the brackets are percentages.

depends on the weather and climatic conditions, the frequency and intensity of these conditions matter (FAO, 2021b). Accordingly, people working in the avocado industry are exposed to the risks associated with these conditions, some of which are specific to avocado production and others are common across agriculture (Australian Centre for Agricultural Health and Safety, ACAHS, 2015). They are also exposed to the hazards associated with the production process including the mechanical hazards caused by the use of machinery and transportation of produce, hand tools such as chainsaws, secateurs, and knives, associated with manual handling in the field and in packing sheds as well as the biological hazards, such as moulds, saps and infectious diseases like leptospirosis, and legionella as well as a number harmful pests (ACAHS, 2015).

Examples of pests include the Avocado Thrips (Scirtothrips perseae) which are famously known as a key pest in most orchards that scars the avocado fruit (Hoddle & Morse, 2003). This "alligator skin" is not commercially acceptable, leading to the avocado's downgrading and extended economic loss for the farmer (*ibid*). According to Faber et al. (1996), other common pests of primary concern for avocado include the Amorbia (Western Avocado Leafroller), Avocado Brown Mite, Greenhouse Thrips, Omnivorous Looper, Persea Mite, Polyphagous Shothole Borer, and Kuroshio Shothole Borer, Sixspotted Mite. Aphids, White Flies, Cutworms, and leaf miners are more likely to become a problem in the avocado plant nursery (Faber et al., 1996). Additionally, young avocado plants in the field are in danger from Branch and Twig Borer, European Earwig, False Chinch Bugs, Fuller Rose Beetles, Grasshoppers, and June Beetles (*ibid*).

Avocado producers are also exposed to hazards associated with the use of chemicals like insecticides, fungicides, and herbicides (ACAHS, 2015). Unfortunately, the burden of all these disasters is largely borne by the poor, including the smallholder farmers whose coping strategies are generally weak. Risk-resilient development pathways are therefore necessary to build disaster-resilient agricultural systems that will be capable of improving the livelihoods of present and

future generations, even in the face of mounting threats.

3.3. Perceptions of the Effects of Avocado Production on Biodiversity

The respondents were also asked to indicate whether they agreed or disagreed with each of the seven statements that explored the effects of avocado production on biodiversity (see details in Table 2). The summary of the results of the opinion ranking is presented in Table 11. In addition, the same table also shows the results of the inter-district comparison of mean ranks for the two study districts (Hai and Rungwe); and for the pooled sample. For the pooled sample, the mean ranks for individual variables or statements ranged from the smallest of 3.1417 (for the "flora" variable) to the largest of 4.4083 (for the "fertility" variable). The results of the inter-districts comparison show that the Rungwe district recorded mean ranks ranging from the smallest of 3.0972 for the "fauna" variable and the largest of 4.4583 for the "fertility" variable. The Hai district registered the lowest mean rank of (3.1042) for the "flora" variable and the highest mean rank of 4.3333 for the "fertility" variable. Thus, the "fertility" variable recorded the highest mean rank in both the Rungwe and Hai districts.

The "fertility" variable represented the statement that the "shift from the production of annual crops to avocado, which is a perennial crop, has helped to control soil erosion and has improved soil structure and fertility, increased ecosystem nutrient retention, carbon sequestration, and water infiltration, and it has therefore helped to conserve soil organisms or biodiversity." The "flora" variable represented the statement that "by enhancing soil fertility, water retention, and infiltration avocado trees improve ecosystem health and support several understory vegetation and soil flora." The "fauna" variable represented the statement that the "avocado trees support many fauna species that live in soils, on trees, and in the understory vegetation including insects, bees, beetles, butterflies, birds, lizards, tree frogs, and others."

There were significant inter-district differences in opinions about the effects

Table 11. Differences in perceptions of the effects of avocado production on biodiversity between the study districts.

Code	Variable	Hai		Rungwe		Pooled sample		t	Sig.
		M	STDV	M	STD	M	StDev		
1	Fertility	4.3333	0.5580	4.4583	0.52908	4.4083	0.54200	−1.240	0.217
2	Water	3.8750	0.48925	4.1528	0.46451	4.0417	0.49188	−3.142	0.002
3	Flora	3.1042	0.80529	3.1667	0.62799	3.1417	0.70169	0.476	0.635
4	Fauna	3.5625	0.82272	3.0972	0.60885	3.2833	0.73546	−3.354	0.001
5	Education and public awareness on biodiversity	3.9375	0.72658	4.0556	0.3711	4.0083	0.54226	1.039	0.303
6	Habitat protection	3.9167	0.64687	4.0972	0.34231	4.0250	0.49302	1.775	0.081
7	Environment	4.2500	0.91093	4.3750	0.63772	4.3250	0.75773	−0.825	0.412

of avocado farming on biodiversity, especially for "water" ($p = 0.002$) and "fauna" indicators ($p = 0.001$) in which the Rungwe district registered relatively larger values than the Hai district. The "water" variable represented the statement that "Avocado, like many other perennials, plays an important ecosystem function of enhancing soil water retention as well as moisture infiltration and storage, creating a favourable microclimate buffer zone for soil organisms."

The opinions of respondents regarding the effects of avocado farming on biodiversity can be compared with other views in the literature. There are several authors who have argued that avocado production can put pressure on biodiversity, resulting from changes in water and agrochemical uses as well as land use change (Stoessel et al., 2012; Verones et al., 2012). Regarding water use, for example, Stoessel et al. (2012) argued that avocados are among the top three crops causing water stress. According to this viewpoint, the use of agrochemicals in avocado farming may not only contaminate local soils but agrochemicals may also run off into surrounding water bodies and potentially affect biodiversity in distant ecosystems (*ibid*).

Where irrigation is used, over-abstraction of water may occur and lower water levels negatively affecting the aquatic ecosystems and irrigation, and may also induce other negative ecological impacts, like waterlogging and salinization (Venot et al., 2017). In addition, salinization may lower soil production and negatively affect the ecosystems and the biodiversity adjacent to avocado production areas (*ibid*). The use of pesticides is also harmful to insects and reduces the biodiversity in and around avocado farms (Stoessel et al., 2012).

However, most of these challenges can be addressed by promoting the production of organic avocados. The available evidence shows that the organic avocado market is still a niche (FreshFruitPortal, 2021a, 2021b). More specifically, the challenge of toxic agrochemicals in irrigation systems, for example, can be addressed by applying agrochemicals like fertilizers via advanced irrigation systems and ensuring their efficient use (Stoessel et al., 2012). Of course, accessing the niche markets for avocados would require certification with standards like the GlobalGap which is an internationally recognized standard for farm production and includes criteria such as food safety, environment (including biodiversity), workers' health, safety, and welfare, among others (Apaza et al., 2019; CIRAD, 2019). Other related certifications are the Rain Forest, Tesco, and Fair for Life which aims to reduce harmful environmental impacts like soil and water contamination (Apaza et al., 2019).

4. Conclusion and Recommendation

This paper uses the case of smallholder farmers in Rungwe and Hai Districts, Tanzania who produced avocados for the export market to investigate their opinions regarding the effects of producing the fruit on livelihoods and biodiversity. We found that farmers positively and strongly perceived that there were potential effects, especially in terms of supporting farmers' livelihoods, enabling them

to recover in cases of economic shocks, increasing their portfolios of assets, improving productivity, diversifying their sources of income, and reducing and managing disaster risks. Overall, avocado production was ranked number one as the major source of income for the smallholder farmers in the study districts. Importantly, avocado farming was perceived by farmers as positively improving, not only their livelihoods but also the status of biodiversity due to a number of factors, including increased soil fertility and water conservation as a result of shifting from overreliance on annual crops to including perennial crops (avocado in this case). Normally the perennial crops provide relatively huge tree covers compared to annual crops which in turn lead to increased soil organisms (fauna and flora) and hence improved habitats for the living biota and slowing down the rate of environmental degradation.

As such, the farmers perceived avocado farming as more beneficial than the rest of their income sources, and the benefits of producing the crop outweighed the costs of production. This implies that, if the avocado fruits are produced using more sustainable practices they can hugely contribute to improved livelihoods and biodiversity conservation. However, this requires concerted efforts from all the stakeholders, including the farmers themselves, the avocado exporting companies, policymakers, and other development partners.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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