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Factors Influencing Postharvest Losses in the Avocado Value Chain: A Case of Makambako Town Council, Tanzania

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Abstract: **Postharvest losses can reduce the income earned from avocado production even when fruit is harvested in marketable condition. This article examines handling, storage and transportation challenges in the avocado value chain in Makambako Town Council, Tanzania. It draws on a quantitative cross-sectional survey using purposive sampling. Of 100 questionnaires distributed to value-chain stakeholders, 81 were returned, giving an 81% response rate. Respondents identified poor road conditions (90.1%), market-related delays (87.7%), weather-related delays (72.8%) and vehicle breakdowns (44.4%) as challenges affecting transportation. These findings describe reported difficulties rather than measured quantities of fruit lost. The results suggest that more dependable collection arrangements, careful loading, suitable packaging and improved temporary storage deserve attention alongside road and vehicle conditions. The study was limited to one council and relied on non-probability sampling and self-reported responses. The available field measures were also insufficient to estimate the separate contribution of handling, storage and transportation to postharvest losses. Future work should follow individual consignments through the value chain, record physical and economic losses, and compare findings across routes and seasons. Such evidence would help identify interventions that are both effective and affordable.**

Keywords: **Avocado; Postharvest Losses; Postharvest Handling Practices; Storage Conditions; Transportation Conditions.**

I. INTRODUCTION

Reducing postharvest losses matters not only for the volume of food available to consumers, but also for the income producers retain from what they harvest. Avocado is particularly sensitive to the conditions it encounters after harvest. Damage caused by dropping, compression and repeated loading may not be obvious at dispatch, while unsuitable temperatures and prolonged holding can hasten deterioration before sale. The literature on avocado preservation shows that fruit physiology, mechanical injury and microbial spoilage have to be considered together [1].

These concerns extend beyond any single stage of the value chain. Packaging chosen at a farm can determine how well fruit tolerates a difficult journey; fruit held without ventilation may already be vulnerable when transport arrives. The organisational dimensions of a supply chain are therefore as important as its equipment. Research on cooling and supply-chain organisation illustrates how the potential benefits of refrigeration depend on the wider route and distribution system [2]. In Tanzania, transportation has also been identified as a constraint on avocado market performance [3].

Regional studies provide a basis for the present investigation, but their evidence is not interchangeable. Research among smallholder fruit farmers in Mbeya documents traditional harvesting methods, limited postharvest facilities and damage risks [4]. In Njombe Town Council, a nearby study identified harvesting methods and infrastructural constraints among issues connected with avocado losses [5]. Research in Kenya has linked variation in postharvest losses to farm and

household characteristics, indicating that technical conditions operate alongside access to resources and markets [6]. Meanwhile, work on Tanzania's export-oriented avocado value chains shows that commercial standards and trading relationships affect how produce is classified as loss or waste [7].

The study was guided by three questions: what is the influence of postharvest handling practices, storage conditions and transportation conditions on losses in the avocado value chain in Makambako Town Council? The questions were specified in relation to three operational stages, rather than an open-ended search for every possible cause of loss. The field survey is examined here in light of what its collected measures can substantiate. In particular, the available field questionnaire allows a description of frequently reported transport difficulties, but does not support a verified comparison of regression coefficients for all three proposed predictors. This distinction is maintained throughout the article.

For a study of this type, it is also necessary to distinguish three meanings of loss. Fruit that has rotted represents physical waste; fruit that is edible but downgraded represents quality or economic loss; and fruit rejected by a particular buyer may still be suitable for an alternative market. Studies of changing export requirements in Tanzania indicate that these categories do not always coincide [7]. A survey that asks about problems on the road must therefore be interpreted carefully: it can establish the prominence of a reported difficulty without automatically showing whether its consequences were physical spoilage, a lower price or delayed payment. This distinction guides the interpretation of the Makambako data.

II. LITERATURE REVIEW AND CONCEPTUAL BASIS

A. Postharvest handling practices

Harvesting, sorting, grading, packaging and loading are the first opportunities either to preserve or compromise fruit quality. Evidence from Mbeya shows that damaging harvesting methods remain relevant to smallholder operations [4]. The Njombe study likewise links postharvest problems with harvesting and access to support infrastructure [5]. These studies support examining the handling process as a sequence of decisions rather than only the act of picking fruit. However, the reported figures arise from different samples and measures, so they cannot be assumed to represent Makambako.

B. Storage conditions

Storage conditions include temperature, ventilation, duration and the suitability of temporary holding facilities. Experimental research on avocado demonstrates that storage temperature can influence shelf life, weight loss and chilling injury, while the best temperature depends on the fruit and treatment used [8]. A broader review of perishable-food cold chains identifies infrastructural and operational constraints, including the reliability of equipment and the availability of skills [9]. For farmers who use shaded collection points or ordinary rooms rather than refrigerated facilities, the practical questions concern exposure to sunlight, holding time and the timing of collection as well as access to technology.

C. Transportation conditions

Transport conditions encompass road surfaces, vehicle suitability, loading arrangement, vibration, journey length and delays. A Tanzanian study involving 505 farmers drew attention to the relevance of transport to avocado marketing [3]. Studies in Mbeya similarly report insufficient transport facilities alongside handling and storage concerns [4]. Market distance has also been considered in Kenyan analysis of avocado losses [6]. These sources justify examining transport as part of a connected process, but do not establish a direct causal coefficient for any individual road or vehicle factor in Makambako.

D. Theoretical interpretation

General Systems Theory views a value chain as a set of linked processes whose performance depends on how activities interact [10]. Deming's quality-management approach places greater emphasis on preventing defects through consistent processes rather than relying solely on inspecting the finished product [11], [12]. Applied to avocado, the two perspectives suggest that careful handling, suitable holding conditions and reliable transport need to be managed together. They provide an organising explanation, not proof that the particular variables in this study caused measured fruit losses.

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III. MATERIALS AND METHODS

A. Study area, design and respondents

The research was undertaken in Makambako Town Council, Njombe Region, Tanzania. Its original fieldwork used a quantitative cross-sectional survey. The documented target population was 150 stakeholders, comprising 100 avocado farmers, 40 transporters and 10 agricultural extension officers. Participants were selected purposively because of their involvement in the avocado value chain; the sample was not a probability sample of all producers or transporters in the area.

A total of 100 questionnaires were distributed and 81 were completed and returned, representing an 81% response rate. The response rate describes the proportion of questionnaires returned and should not be interpreted as evidence that the purposively selected sample is statistically representative of Makambako Town Council.

B. Data collection and measurement

The field questionnaire documented respondent characteristics and operational difficulties, using categorical and ordered response options. Questions addressed roads, market delays, weather-related disruption and vehicle breakdowns, among other issues associated with fruit movement. A later section of the dissertation also contains a four-construct Likert-scale regression analysis. Its composite measures are identified in the dissertation as arising from a separate instructional dataset, rather than the original field questionnaire records. Consequently, this paper reports field-survey summaries but does not present those regression estimates as verified estimates from the 81 field respondents.

C. Analytical procedure

Field survey results were summarised using frequencies and percentages. The percentages refer to the share of respondents reporting a transport-related difficulty; they are not loss rates for kilograms of fruit, counts of rejected consignments or monetary losses. Because the questionnaire categories could overlap, their percentages were not summed. The analysis was descriptive and did not claim population-representative estimates from a purposive sample.

The respondent, rather than the avocado consignment, was the unit of analysis. A person reporting poor roads is therefore counted in that category irrespective of the number of trips or quantities transported. Reported difficulties could overlap, so their percentages should not be added together. Since the survey included farmers, transporters and extension officers, experiences may also have varied by role. The published summaries do not permit a consistent comparison of all categories of respondent.

IV. RESULTS

A. Questionnaire participation

Table 1: Questionnaire Response Rate

Questionnaire outcome	Number	Share
Returned and completed	81	81.0%
Not returned	19	19.0%
Distributed	100	100.0%

Of the 100 questionnaires distributed, 81 were returned. This provides a fieldwork basis for describing the respondents' reported difficulties, but not for estimating population prevalence with probability-based confidence intervals.

B. Reported transportation difficulties

Table 2: Transportation Difficulties Reported in the Fieldwork Summary

Reported difficulty	Respondents reporting difficulty
Poor road conditions	90.1%
Market-related delays	87.7%
Weather-related delays	72.8%
Vehicle breakdowns	44.4%

Road conditions and market-related delays were the two most commonly reported transport problems. Weather-related delays were also frequent, while vehicle breakdowns affected a smaller, though substantial, share of respondents. These categories may overlap: the percentages should not be added, and the findings do not indicate that the reported problems were mutually exclusive. The data identify areas of reported operational difficulty, but the available summary does not quantify the physical or monetary loss attributable to each factor.

C. Interpretation of the descriptive findings

Taken together, these results describe where respondents encountered transport-related constraints. Poor roads and market delays were prominent in their accounts, while weather and vehicle breakdowns also formed part of the operational setting. The survey does not demonstrate whether one reported problem caused a larger physical loss than another, nor does it identify how much of the harvested crop was downgraded or discarded. These distinctions matter when turning a survey result into an intervention priority.

V. DISCUSSION

A. The significance of collection and transport disruption

The prominence of road conditions and market delays indicates that respondents encountered difficulties at both physical and organisational points of the journey. A road may increase vehicle vibration, but delay at a collection point can also prolong exposure to heat and repeated handling. The Tanzanian transport study by Tumaini et al. [3] supports treating logistics as a substantive aspect of avocado marketing, while evidence from Mbeya [4] shows that storage and transport constraints commonly coexist. The Makambako responses are consistent with this broader pattern, although they do not establish the independent contribution of each mechanism to measured fruit loss.

Market-related delays deserve particular attention. A journey can be extended by uncertainty about buyers, aggregation arrangements or the timing of vehicle dispatch, even without a vehicle failure. Research on Tanzanian avocado export chains highlights how trading relationships and standards influence where costs and losses are experienced [7]. The current survey does not directly trace those relationships, but the high reported frequency of market delays makes coordination between farmers, transporters and buyers a sensible subject for subsequent investigation.

The distinction between different kinds of delay is consequential for intervention design. If the principal problem is a damaged road, the relevant response may involve routing, speed, vehicle suitability or infrastructure improvement. If the problem is the time spent waiting for a buyer or a truck, a more immediate response might be a predictable dispatch schedule, clearer collection responsibilities or earlier communication. Market-related delay can also occur on a satisfactory road. These possibilities demonstrate why the survey categories should guide further observation instead of being treated as interchangeable explanations of physical loss. On-farm records of harvest time and collection time, accompanied by delivery notes showing arrival and grading outcomes, could help distinguish the two mechanisms in future research.

B. Handling and storage as interacting conditions

The reported transportation difficulties should not be isolated from what happens before departure. Fruit may be damaged when packed in inappropriate containers, stacked with excessive weight or loaded repeatedly. Bruising can remain concealed until ripening makes it visible. The Mbeya and Njombe evidence [4], [5] suggests that attention to harvesting methods and facilities is warranted, while experimental avocado storage research [8] helps explain why environmental exposure during holding can accelerate deterioration. These are relevant mechanisms, rather than measured effects established by the present field questionnaire.

A practical implication is that costly refrigeration is not the only possible starting point. Shaded loading areas, shorter waiting times, clean and ventilated temporary storage and protective containers may address some exposure pathways. Such options should nevertheless be tested against actual loss measurements and local costs before being promoted as proven interventions. The cold-chain literature itself demonstrates that facilities and infrastructure operate within wider supply-chain arrangements [2], [9].

C. Interpretation through the theoretical framework

The findings fit the systems argument that weakness at one point may affect later activities. Road delays, market arrangements and holding conditions are operationally connected, so improving transport schedules without addressing

loading and temporary storage could leave important sources of damage in place [10]. Deming's approach likewise draws attention to routine procedures, preventive controls and recording problems as they arise [11], [12]. In this setting, simple records of collection time, loading practice, journey duration and rejection at delivery would provide more useful process evidence than retrospective accounts alone.

The findings also raise an equity question for smaller producers. A farmer may be unable to buy ventilated crates or pay for dedicated transport, even while recognising that existing arrangements create risks. In addition, an improvement that is affordable for a large buyer may shift new costs to smaller suppliers. The literature on value-chain standards suggests that losses and the costs of preventing them are not always distributed evenly [7]. For this reason, proposed improvements should be assessed not only for technical effectiveness but also for who pays for storage, packaging, handling and transport. Local trials could compare shared crates, group collection schedules and individual arrangements, while observing the volume of saleable fruit and the prices received.

D. Study limitations

The study was confined to one town council and relied on purposive participation, limiting broader generalisation. Responses refer to reported operational problems and were not linked to consistently measured changes in fruit weight, market grade, spoilage or price for identified consignments. The questionnaire also did not contain validated and fully documented scales for all three explanatory variables and the postharvest-loss outcome. As a result, the reported frequency of difficulties cannot establish causal effects or the unique contribution of each factor. The instructional regression exercise included in the dissertation is not treated as a field result in this paper. Future field analysis should connect questionnaire indicators directly to identifiable consignment outcomes.

VI. CONCLUSION AND RECOMMENDATIONS

The Makambako survey shows that difficulties associated with roads, market arrangements and weather were frequently reported by avocado value-chain stakeholders. Vehicle breakdowns were also reported, though less often. Together, these findings indicate that the movement of harvested fruit can be affected by infrastructure, scheduling and the organisation of collection and marketing. The study does not quantify the amount of fruit lost through each route of deterioration, but it identifies practical points at which handling and transport arrangements warrant closer examination.

Farmers, transporters, traders and extension services should consider more reliable collection schedules, careful loading, protective containers and suitable shaded holding areas. Recording dispatch times, delivery times and fruit condition at transfer points could also make problems easier to identify. These measures should be assessed together because poor packaging can intensify damage during a difficult journey, while delays can lengthen exposure to unsuitable storage conditions.

Further research should follow identifiable consignments from harvest to sale and record actual losses in quantity, quality and value. Such studies should measure handling methods, storage conditions and transport characteristics consistently across different journeys and seasons. A validated dataset could then be used to examine how these factors are associated with postharvest losses, while accounting for relevant farm and market characteristics.

A small field pilot would provide a practical starting point. Participating producers could keep a common record of harvest date, packaging, storage arrangements, dispatch time, route, delivery time, buyer grade and weight accepted or rejected. Comparing such records before and after changes in collection schedules or packaging would provide stronger evidence of whether the intervention reduces losses. Cost and feasibility would also need to be assessed so that improvements do not place an unreasonable burden on smaller producers.

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