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Assessment of potato tuber quality in Kenya

Baseline quality assessment survey report

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EXECUTIVE SUMMARY

Potato is the second most important staple crop in Kenya after maize, supporting its food security and providing livelihoods for millions in the value chain, including over 800,000 smallholder farmers. However, fragmented marketing systems, inadequate post-harvest infrastructure, and limited access to quality inputs constrain the performance of the sector and result in severe post-harvest losses. This qualitative study provides empirical analysis on potato tuber quality among 233 farmers in Nakuru and Nyandarua counties, and among traders six different main markets in Kenya. Our findings establish a baseline for potato quality at the farm-level and in major markets, tracking individual shipments to measure degradation during transit due to lack of crucial market conditions and logistical bottlenecks.

Our main results reveal some important elements that need to be addressed. Overall, potato quality is compromised at the farm gate, but this initial damage is dramatically amplified post-harvest, with skin abrasions more than doubling and rotting increasing threefold as produce moves along the value chain. Critically, these losses are compounded by limited quality-based sorting and the inadequate use of storage infrastructure, with negligible adoption of cold storage. The study also demonstrates that local/traditional handling practices and poor infrastructure quality are bigger drivers of loss than transport distance.

Our research concludes that most economic losses could be addressed, being the direct result of identifiable failures in infrastructure, handling, access to information, and quality governance throughout the value chain. Most aspects of which can be mitigated with digital tools. Indeed, digital tools can enhance farmer-buyer linkages, promote digital education and advisory services -also through collaboration with Farmer Service Centers, encourage cold storage via digital incentives. These recommendations position digital tools as a catalyst for transforming the potato value chain, both directly and indirectly mitigating post-harvest losses while boosting resilience and incomes.

MUHTASARI WA RIPOTI

Viazi ni zao la pili kwa umuhimu nchini Kenya baada ya mahindi, likichangia pakubwa katika usalama wa chakula pamoja na kutoa riziki kwa mamilioni ya watu katika mnyororo wa sekta ya viazi, wakiwemo wakulima wadogo zaidi ya 800,000. Hata hivyo, mifumo ya uuzaji iliyotawanyika, miundombinu duni baada ya mavuno, na ufikiaji mdogo wa pembejeo bora vinaathiri uwezo wa sekta hii na kusababisha hasara kubwa baada ya mavuno Utafiti huu unatoa uchambuzi wa kina kuhusu ubora wa viazi miongoni mwa wakulima 233 katika kaunti za Nakuru na Nyandarua, na wachuuzi katika masoko makuu sita nchini Kenya. Matokeo yetu yanaweka msingi wa ubora wa viazi kuanzia shambani na katika masoko makubwa, yakifuatilia mizigo binafsi kupima uharibifu wakati wa usafirishaji kutokana na ukosefu wa hali muhimu an bora za soko na changamoto za kilojistiki na usafirishaji.

Matokeo yetu makuu yanaonyesha baadhi ya vipengele muhimu vinavyohitaji kushughulikiwa. Kwa ujumla, ubora wa viazi huanza kuathirika kutoka lango la shamba, lakini uharibifu huu huongezeka kwa kasi baada ya mavuno; michubuko ya ngozi huongezeka zaidi ya mara mbili na kuoza huongezeka mara tatu kadri mazao yanavyosonga kwenye mnyororo wa thamani wa viazi. Muhimu zaidi, hasara hizi huchochewa na uchambuzi mdogo wa mazao kulingana na ubora na matumizi duni ya miundombinu ya uhifadhi, huku kukiwa na matumizi madogo mno ya maghala na vifaa vya kuhifadhi baridi (cold storage). Utafiti pia unaonyesha kuwa mbinu za kienyeji za kutunza mazao na ubora duni wa miundombinu ni vichochezi vikubwa vya hasara kuliko umbali wa usafiri.

Utafiti wetu unafikia hitimisho kwamba hasara nyingi za kiuchumi zinaweza kutatuliwa, kwani zinatokana moja kwa moja na mapungufu yanayoonekana katika miundombinu, ushughulikiaji wa mazao, upatikanaji wa taarifa, na usimamizi wa ubora katika mnyororo mzima wa thamani. Vipengele vingi kati ya hivi vinaweza kupunguzwa kwa matumizi ya zana za kidijitali. Hakika, vifaa vya kidijitali vinaweza kuimarisha uhusiano kati ya wakulima na wanunuzi, kukuza elimu ya kidijitali na huduma za ushauri—ikiwemo kupitia ushirikiano na Vituo vya Huduma kwa Wakulima (FSCs), na kuhamasisha matumizi ya hifadhi baridi kupitia vivutio vya kidijitali. Mapendekezo haya yanaweka teknolojia za kidijitali kama kichocheo cha mageuzi katika mnyororo wa thamani wa viazi, yakisaidia kupunguza hasara baada ya mavuno na wakati huo huo kuongeza ustahimilivu na mapato.

1. INTRODUCTION

The potato subsector is the second most important staple crop subsector in Kenya after maize, playing a critical role in national food security and as a source of income for over 800,000 smallholder farmers (CIP, 2019). Overall, the value chain employs about 3 million producers, middlemen, traders, processors and other marketers (Maingi et al., 2015). Despite its significance, the subsector is characterized by persistent structural and operational challenges that limit its full potential. These constraints include an unstructured or fragmented marketing system (due to the dominance of unregulated middlemen), inadequate post-harvest handling infrastructure, and limited access to high-quality inputs, which collectively contribute to high production costs and market volatility (Kaguongo et al., 2014). The most critical consequence of these challenges is the significant post-harvest loss (PHL), which is estimated to be as high as 30-40 percent of the total harvest, a figure that represents both quantitative and qualitative losses (NPCK, 2025). The reasons for both quantity and quality losses are largely similar, with the extent of damage being the main determinant of low marketability. Therefore, some quality losses are then discounted, and the produce is sold at a lower price. This result is in line with Delgado et al. (2020), who explicitly analyze quantity losses and quality deterioration together, arguing that pre-harvest conditions and qualitative losses have direct impacts on eventual losses at later stages of the value chain. The overall level of loss ultimately impacts the profitability and sustainability of the value chain, with a price punishment for inferior produce. The burden of these losses disproportionately affects most smallholder producers (Kaguongo et al., 2014). Addressing the drivers of quality loss is therefore critical to transforming the subsector into a robust, competitive, and sustainable industry.

This study, a collaboration between the National Potato Council of Kenya (NPCK), the International Food Policy Research Institute (IFPRI), and the International Potato Center (CIP) was specifically designed to generate empirical qualitative evidence on potato tuber quality, complementing the quantitative research on digital tools integration, biodiversity, and the potato value chain in Kenya (Boukaka, 2025).

The core objective of this study is to investigate the characteristics and underlying causes of post-harvest losses due to inadequate produce quality in the potato value chain in Nakuru and Nyandarua. By analyzing tuber quality at two critical junctures -the farm gate (origin) and major fresh produce markets (destination)- the research seeks to trace the extent and nature of quality degradation, along with the identification of the key drivers of these losses throughout the value chain, complementing the quantitative baseline survey to assess the impact of digital tools training on socio economic indicators among Farmer Service Centers (FSCs) and associated farmers they serve. Taken together, the lesson learned can then be used for policy recommendations.

As a multi-stakeholder Public-Private Partnership (PPP), NPCK is mandated to plan, organize, and coordinate activities across Kenya's potato value chain. NPCK played a pivotal role in leading data collection and physical quality assessments, drawing on its extensive network and sector-specific expertise. CIP served as a key technical partner, bringing its global expertise in potato research and value chain development. Meanwhile, IFPRI provided overarching research design, including initial respondent lists and the sampling framework, ensuring the study's methodological rigor.

The remainder of this report is organized into six sections. Section 2 presents the survey methodology; section 3 reports the baseline condition of tubers immediately after harvest; section 4 documents tuber condition at terminal markets; section 5 presents findings from the shipment tracking component; section 6 examines the storage infrastructure; finally, section 7 synthesizes key findings, identifies primary drivers of post-harvest loss, and outlines actionable recommendations.

2. SURVEY METHODOLOGY

2.1. Study design

To comprehensively characterize tuber quality at critical nodes of the value chain, a specific data collection methodology was designed. This approach paired single-point quality assessments with follow-through tracking of individual produce consignments to capture not only static quality snapshots but also the dynamic processes of degradation. The strategy consisted of three integrated components:

i. **Farm-gate quality baseline**: An assessment was performed by drawing a sample of 21 tubers from the producer's total harvested volume at the point of origin (the farm gate), immediately following the harvest. The objective was to establish a definitive baseline of intrinsic tuber quality, documenting key attributes before the product was subjected to the stresses of transportation and market handling. This benchmark served as the reference point for all subsequent measurements of quality change.

ii. **Destination market quality assessment**: A parallel evaluation was executed at major potato markets, to document the end-point quality status of a subset of tubers sampled at the farm gate as they reach final distribution points. This market-level assessment captured the cumulative handling effects in storage, packaging, and transportation, revealing the actual quality of produce available to wholesale buyers, retailers, and ultimately consumers. The assessment protocol examined the same quality parameters as the farm-gate evaluation, enabling direct comparative analysis across the value chain.[1]

iii. **Delivery tracking**: This component involved tracking individually tagged shipments from farm gate through to their final destination at the market. By assessing the same batch of tubers at both the start and end of the journey, this component created a direct empirical link between the two points. This powerful design made it possible to isolate and precisely quantify the extent of quality degradation attributable specifically to post-harvest handling and transit, filtering out confounding variables such as initial differences in farm-level produce quality.

2.2. Sampling and data collection

Field data collection was conducted between July 30 and August 13, 2025, a two-week period selected to coincide with the main harvest season. This period was identified as the best to capture optimal market activity and ensure representative sampling of commercial potato flows through the value chain.

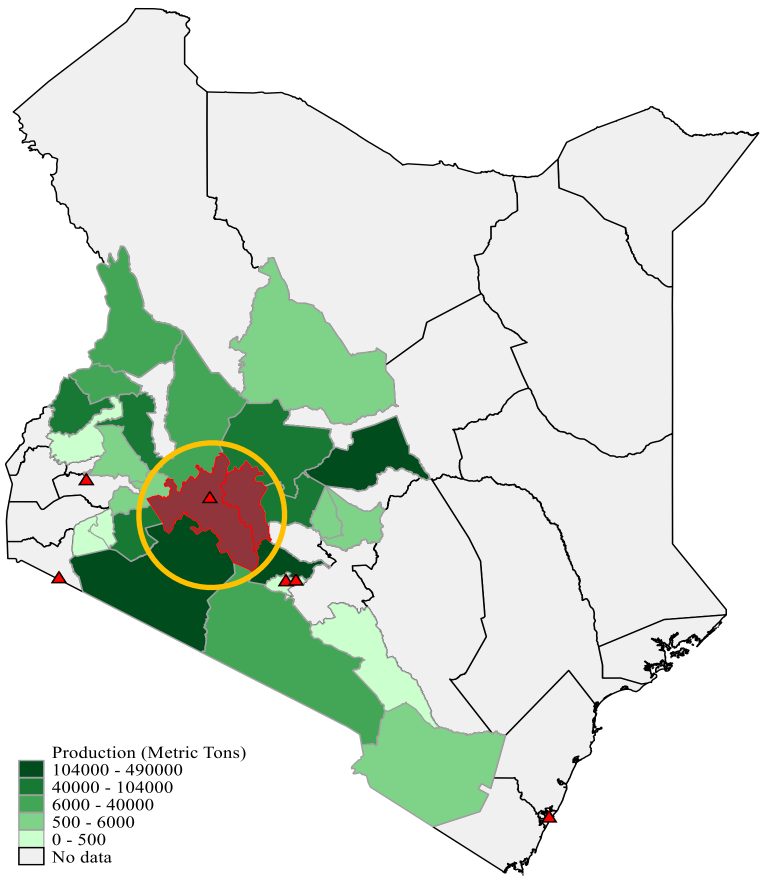
At the farm-gate, a random sample of 233 assessments were successfully completed across the two primary potato production regions of Kenya: Nakuru and Nyandarua. Nakuru County is a major commercial production hub characterized by a combination of large-scale and small-scale farming operations with established market linkages, while Nyandarua County is a traditional potato production zone, mostly dominated by smallholder farming systems. Although the study design had planned to draw a subset of farmers directly from the respondent list of the concurrent digital tools quantitative survey, asynchronous harvesting calendars necessitated an adaptive sampling strategy. Consequently, the final sample com-

[1] At the onset of the project this parallel evaluation was envisaged to be conducted through sensors (SoilTech devices). However, the team later adopted a tuber qualitative evaluation both at the farm gate and the market -adding a tracking component- to enrich comparability and increase the set of characteristics under analysis.

prised a hybrid of producers from the quantitative survey and additional farmers within the broader network of local Farmer Service Centers (FSCs)[2]. To identify active harvest points, enumerators coordinated with FSCs to identify farmers harvesting on the specific day of the visit.

To ensure the tuber assessments were representative of the producer's total yield, a strict sub-sampling procedure was applied. Assessments were conducted on the aggregated harvest pile prior to packaging. From this aggregate, enumerators randomly drew a sub-sample of 21 tubers using a multi-point sampling technique—collecting tubers from the top, middle, and bottom layers of the heap—to avoid selection bias associated with only picking visible surface tubers.

Figure 1. Average potato production (2020-2024) and key markets in Kenya



Source: Constructed from the Kenya AFA Year Books of Statistics data (AFA, 2025)
Note: Nakuru and Nyandarua are the maroon shaded counties inside the yellow circle. Red triangles indicate markets assessed.

The market-level evaluation encompassed 54 assessments distributed across six major fresh produce terminals, capturing diverse market types and geographical reach. This included the following regional market hubs: Wakulima Market in Kisumu (Western Kenya's primary distribution center serving cross-border trade routes), Sirare Market in Migori (a key border market facilitating regional trade with neighboring countries), and Wakulima Market in Nakuru (a central collection point serving both local consumption and redistribution to other regions). Additionally, produce was assessed at the following metropolitan distribution centers: Marikiti and Ruai Markets in Nairobi (dual assessment points in the capital city representing the country's largest consumption center and primary wholesale distribution network) and

[2] A Farmer Service Centre (FSC) is an agripreneur-led, commission-based microbusiness that acts as a last-mile service hub, bundling inputs, advisory, and market linkages for smallholder farmers while leveraging digital tools to bridge gaps in the agricultural value chain.

Kongowea Market in Mombasa (the coastal region's main fresh produce terminal representing the longest transport distance from production areas). This purposive selection framework ensured comprehensive coverage of short-haul regional markets and long-distance metropolitan destinations, capturing the full range of logistical challenges and quality implications across varying transport durations and handling intensities.

Within these markets, a systematic selection approach was employed to ensure diverse representation. Enumerators randomly selected traders at intervals between the market lanes. For the physical assessment, one specific 50kg+ sack was randomly selected from the trader's stock. To mitigate *top-of-sack* bias - where quality may appear better or worse due to settling or stacking - the 21 tuber sub-sample was drawn from three distinct depths (upper, middle, and lower sections) either by carefully burrowing into the sack or during the process of emptying the contents for display.

A total of 39 distinct potato bags were tagged, tracked, and assessed at their farm of origin and then reassessed upon arrival at their destination market. This tracking cohort represents approximately 17 percent of farm-gate assessments.

2.3. Quality assessment

To ensure a systematic, objective, and replicable evaluation of potato quality, a comprehensive assessment framework was developed and applied across all data collection points (farm gate, market, and tracked shipment). The evaluation protocol took into account the international potato quality standards (UNECE-FFV-52) adapted to local market conditions, with NPCK taking the lead (UNECE, 2023). It was designed to capture a multidimensional view of tuber quality, encompassing not only the physical and physiological attributes of the tubers but also the associated handling and post-harvest practices.

All physical tuber assessments were conducted by enumerators who underwent intensive training to ensure reliability. The training involved detailed instructions on standardized protocols, the use of visual aids depicting various defects, and calibration exercises where teams assessed the same samples to align their scoring. For each unit (the farm or the tracked shipment to the market), a random sub-sample of 21 tubers was drawn from multiple bags to ensure the representativeness of the entire lot. Each tuber in the sub-sample was individually inspected. Data was recorded on standardized digital forms, which minimized entry errors and streamlined data aggregation.

The specific measurement of quality within these samples involved distinct physical tests for external and internal attributes. External quality was assessed visually and manually: size was categorized using standardized measuring cards (<50mm, 50–80mm, and >80mm), while physical maturity was evaluated through a "skin set" test assessing resistance to peeling.[3] Defects were recorded based on presence and classified by severity—distinguishing between slight/moderate defects and severe defects. Internal quality was assessed by cutting a subset of tubers longitudinally to identify defects such as hollow heart or vascular discoloration. Analytically, the recorded defect frequencies for each parameter were then converted into prevalence rates (the proportion of tubers in each sample exhibiting a given defect), serving as the primary metric for comparing quality across value chain stages.

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[3] The "skin set" test is an assessment used to determine physiological maturity and curing status. It involves applying gentle thumb pressure or friction to the tuber surface. Mature tubers with fully developed skin set exhibit firm resistance and the skin remains intact, indicating readiness for harvest, handling, and storage. Immature tubers display loose or "feathering" skin that peels easily under light pressure, signaling incomplete curing - the natural process by which potato skin toughens after harvest. Tubers with poor skin set are highly susceptible to moisture loss, disease entry, and mechanical damage during post-harvest handling and transport.

Image 1: Visual representation of a packed bag, dirty heap, clean tubers, and internal discoloration

Source: NPCK data collection exercise

The questionnaire was designed around a multi-stage physical inspection protocol intended to generate an overall quality profile. The tool's assessment modules were structured around three core categories of quality parameters.

I. External quality attributes

This category focused on characteristics visible on the tuber surface, which are primary drivers of consumer perception and initial purchase decisions. Enumerators reported tuber's general appearance, including differences in size and shape, skin finish (smoothness/netting), and cleanliness (presence of soil). They also examined physical damage, which referred to mechanical injuries incurred during harvesting and handling, including cuts and punctures caused by tools or sharp objects, bruises and abrasions resulting from impact or friction and serving as indicators of potential decay, and cracks arising from handling or environmental stress. Further assessment covered physiological disorders such as greening, which occurs when chlorophyll develops under light exposure and is associated with solanine presence, and sprouting, which signals age, dormancy break, or unsuitable storage temperatures. Pest and disease damage was also documented, including late blight manifested as dark, sunken lesions and potato tuber moth symptoms such as entry or exit holes and tunneling beneath the skin.

II. Internal quality attributes

A subset of tubers from the sample was also cut open longitudinally. This was crucial for identifying defects that affect the usable portion of the tuber and processing quality. Internal appearance was evaluated with respect to flesh color and texture. Internal physiological defects were identified, including hollow heart characterized by a star-or lens-shaped cavity caused by rapid, uneven growth, black spot bruising signaled by grey or black tissue discoloration caused by impact with no skin break, and internal brown spot reflected in irregular necrotic patches. Internal pest and disease presence was also inspected, including larvae of the potato tuber moth or the progression of bacterial or fungal rots such as brown rot and soft rot that might not be fully evident externally.

III. Handling and post-harvest characteristics

The framework incorporated documentation of external factors influencing quality degradation. Packaging characteristics were recorded, including material type such as woven polypropylene or woven jute bags, the condition of the bags, and the standard weight per bag, all of which influence aeration, moisture control, and compression damage. Storage conditions, where applicable, captured the method used, whether left at the farm, stored in a dedicated facility, or kept in a lorry. Duration of storage was also reported at both the farm and market.

3. QUALITY AT THE FARM GATE

The farm-gate assessment establishes the critical baseline quality profile of tubers entering the value chain. This stage represents the *quality ceiling* for the crop; any defects present at harvest are an intrinsic problem rooted in agronomic or harvesting practices that cannot be corrected post-harvest. In fact, these defects are highly likely to reduce initial market value and increase sensitivity to further losses during handling, transport, and storage, such as rot, weight reduction, or downgrading. Even modest average percentages can result in substantial absolute losses at scale, leading to supply-chain inefficiencies like increased sorting, higher rejection rates, and lower prices.

The identification of tuber defect profiles and their prevalence at harvest was based on the mean percentage of affected tubers. Our procedure involved randomly selecting 21 potatoes from the harvested heaps at the farmgate. For every defect group in the dataset, such as cracks and pest damage, we computed the prevalence as the proportion of potatoes within each sample exhibiting that specific quality loss. This methodological protocol was implemented uniformly across all samples, including both market and tracked potatoes.

The overwhelming dominance of the *Shangi* variety (cultivated by 90 percent of producers) is a crucial factor in post-harvest conditions. The *Shangi* variety is preferred for its high yield and rapid maturity but is associated to notably poor storage quality, tending to sprout or soften quickly after harvest (Abong et al., 2015). This inherent physiological trait shapes farmer decisions, favoring immediate sale over quality preservation. In contrast, while processing or ware varieties offer better storage characteristics and resilience to handling, their lower prevalence suggests that the current value chain is optimized for the rapid turnover required by the *Shangi* variety. *Dutch Robijn* and other Dutch processing varieties are reported to be associated to good storability and high dry matter, and are preferred by large-scale processors; *Shangi* potatoes are difficult to store and leads to high losses during processing (Naziri et al., 2024).

Image 2: Enumerator collecting a sample tuber for assessment

Source: NPCK data collection exercise

Data collected at the farm gate indicates that while cosmetic and grading issues - specifically dirtiness and size - are the most widespread concerns, most agronomic and pathological defects fall into the moderate category. This suggests that most affected potatoes retain their marketability despite a reduction in value, whereas severe defects like small size or specific rotting render the crop entirely unmarketable. The results distinguish between the physical volume of the crop affected and the breadth of the issue across the agricultural community, showing how a defect might affect a small portion of the total harvest yet be a common problem shared by nearly all producers. Table 1 details the prevalence of defects, aggregating both slight/moderate and severe instances[4] to provide a total percentage of affected tubers and the proportion of farmers affected by each defect.[5]

Mechanical damage constitutes a highly prevalent category of defects, reflecting aggressive lifting practices. Feathering or skinning was the most frequent mechanical defect, affecting 15 percent of sampled tubers. This high rate of skinning points to premature harvesting before the tuber skin has adequately set (matured). Closely related to this are bruising (15 percent), cuts (11 percent), and internal physical damage (6 percent). While feathering was the most common defect by volume, cuts were the most widespread issue among producers, observed in 76 percent of the farmers surveyed. The combination of

[4] Tubers are categorized as slight/moderate if they exhibit minor defects (e.g., surface scuffs), potentially warranting a discounted sale or lower-grade usage, whereas severe defects render them unmarketable or unsuitable for sale (e.g., deep rots), necessitating disposal or special allocation.
[5] A single tuber can present more than one defect, and that the prevalence figures are not mutually exclusive. Consequently, the sum of all defect percentages does not equal the proportion of defective tubers in the sample.

these mechanical defects results in the immediate compromise of the tuber's protective skin layer, allowing pathogens to enter the tuber through bruises, wounds, or cuts. This renders the crop highly vulnerable to secondary rot and moisture loss during storage (NPCK, 2018).

Table 1: Prevalence of primary tuber defects at farm gate

Defect Category	Specific Defect	Tubers (%)			Farmers (%)		
		Slight/ Moderate	Severe	Total Affected	Slight/ Moderate	Severe	Total Affected
Agronomic & Physiological	Growth Cracks	6.7	0.5	7.3	33.5	8.2	36.9
	Greening	5.4	0.8	6.2	43.8	6.0	44.2
	Sprouting	5.5	0.4	5.8	19.3	2.2	20.2
	Internal Discoloration	2.2	0.3	2.5	22.8	2.2	23.2
	Malformation	7.4	0.4	7.8	49.4	3.9	50.2
	Hollow Heart	1.3	0.0	1.3	7.7	0.0	7.7
	Blackheart	-	0.3	0.3	-	4.3	4.3
Mechanical	Internal Physical Damage	5.3	0.7	6.0	45.1	7.7	46.8
	Feathering/Skinning	13.6	1.4	15.0	49.8	6.0	49.8
	Cuts	9.9	1.2	11.1	74.7	13.3	76.4
	Bruising	10.9	4.0	14.9	37.8	9.9	39.5
Pathological	Pest Damage (External)	5.1	0.3	5.4	60.1	3.0	60.1
	Pest Damage (Internal)	2.7	0.1	2.9	33.1	1.3	33.1
	Disease Damage (External)	4.8	0.4	5.3	33.1	5.2	35.2
	Disease Damage (Internal)	2.2	0.5	2.7	25.8	6.0	29.2
	Rotting (External)	1.2	0.3	1.5	17.6	5.6	21.9
	Rotting (Internal)	1.6	0.5	2.1	20.6	6.4	24.5
Cosmetic & Grading	Misshapen tubers	18.9	1.2	20.1	69.5	10.7	70.0
	Small tubers	-	51.0	51.0	-	85.8	85.8
	Dirty tubers	60.0	20.7	80.7	85.8	38.2	95.3
	Shriveled/flabby tubers	-	2.9	2.9	-	8.6	8.6
	Immature tubers	-	5.5	5.5	-	14.6	14.6

Notes: (1) Number of observations = 233. Total Percentages represent the sum of slight/moderate and severe defects as recorded in the assessment. (2) Slight or moderate defects reduce value but still allow the tuber to be sold, whereas severe defects render it unmarketable.

Source*:* Authors' computation from the Kenya potato quality assessment data (2025).

Agronomic and physiological defects reflect the growing conditions and soil management. In particular, physiological disorders in potatoes can be caused by improper crop management, inadequate storage or handling, extreme temperatures, and imbalances in soil moisture or nutrient levels (Mikitzel, 2014). For example, malformation (7.8 percent) and growth cracks (7.3 percent) are often linked to inconsistent soil moisture levels and poor soil structure during the tuber bulking phase[6]. Malformation was particularly pervasive, reported by half of the farmers surveyed (50 percent). Notably, greening affected 6.2 percent of the potato harvested and was observed in the harvest among 44 percent of farmers. This is a direct result of insufficient earthing-up (hilling) in the field, exposing tubers to sunlight. Apart from visual quality loss, greening indicates the presence of solanine (Meyhuay, 2001), potentially rendering the tubers unsafe for consumption and reducing tuber quality and marketability for consumption and processing.

Pest damage was a major issue, affecting 5.4 percent of tubers externally and an additional 2.9 percent internally. This defect is notably widespread, with 60 percent of farmers dealing with external pest damage. This high prevalence confirms intrinsic quality loss originating from pre-harvest agronomic issues,

[6] See Appendix C: Trader exposure to cracked tubers (61 percent) was notably higher than farmer reports (37 percent).

likely due to inadequate implementation of Integrated Pest Management (IPM) (e.g., insufficient potato tuber moth control) or the use of compromised seed. Small-scale farmers often plant seed tubers acquired through the informal seed system, that lead to quality losses due to an accumulation of pathogens and pests in planting material over successive cycles of vegetative propagation (Thomas-Sharma et al., 2015). Additionally, disease damage affected 5.3 percent of tubers externally and 2.7 percent internally. While severe cases were relatively low, the presence of moderate disease damage introduces pathogen inoculum into the supply chain, posing a high risk of cross-contamination during storage.

The cumulative effect of these defects is substantial. While severe defects are generally below one percent per category, the slight or moderate defects are more pronounced. A closer examination of the potato produce reveals several issues, including a high incidence of cosmetic and grading defects, such as misshapen tubers (20 percent) and dirty tubers (81 percent). The presence of these defects and conditions at harvest underscores the urgent need for improved agronomic practices, better timing of harvest, and more careful initial handling techniques to raise the baseline quality of the crop. The combined effect of these defects means that a substantial portion of the harvest is already downgraded before it even leaves the farm gate. Appendix C provides graphical representation of all defect distributions with confidence intervals, illustrating the precision of prevalence estimates across value chain stages.

4. QUALITY OF TRACKED TUBERS

4.1 Overview of tracked load quality

The tracked load assessment aimed to validate and corroborate defect patterns observed in the market assessment and determine whether traders actively dispose of spoiled or severely defected produce upon arrival at market destinations before selling to traders. By monitoring 39 shipments from farm gate to secondary and tertiary markets, this component captures the transitional quality of tubers, where inherent farmgate issues are often exacerbated by factors such as loading procedures, transit conditions, unloading protocols, and short-term storage at destination markets. Quality losses documented at this stage reduce the marketable fraction of potato produce, necessitate increased sorting efforts, and ultimately compress profit margins for market traders.

4.2 Profile of tuber defects in tracked loads

The defect distribution observed in tracked consignments demonstrates patterns that largely corroborate market-level findings. The persistence of high defect levels from origin to destination suggests limited quality-based culling or sorting interventions during the logistics phase. Table 2 shows the defect profile of tracked loads across agronomic, physiological, mechanical, pathological, and cosmetic categories.

This assessment emphasizes the impact of the logistics chain, showing high levels of transit-related wear such as skinning and bruising. These findings are categorized to show the transition from slight damage, which impacts the visual appeal and price, to severe damage that results in total loss at the point of delivery. Because this table focuses on the journey of the produce, the tubers data serves as a direct measure of cargo integrity, interpreting how much of the total volume survived the transport process in a sellable state versus the portion that arrived unfit for the market.

Similar to the market level defects, mechanical damage was the most prevalent defect category in tracked loads. Feathering (skin abrasions) affected 50 percent of tubers (40 percent moderate; 10 percent severe), compared with 39 percent at major markets and typical farm-gate levels that are more than three times lower. This pattern is consistent with cumulative abrasion and impact during loading, transport over rough roads, and unloading, where tubers repeatedly contact sack materials, vehicle surfaces, and other tubers (Table 3).

Cuts were recorded on 21 percent of tubers in tracked loads (18 percent at major markets), with 5.1 percent classified as severe. Bruise affected 17 percent of tubers (16 percent at markets), and internal physical damage was present in 11 percent of tubers compared with 7.1 percent at markets.[7] The similar defect rates in tracked loads and market samples show that mechanically damaged tubers are not removed during transit, so traders receive them as part of the consignments. As a result, any culling of damaged potatoes occurs at the market after shipment is delivered to traders.

Cosmetic defects in tracked loads closely matched those observed at markets. Dirty tubers were the most common issue, affecting 83 percent of tubers (59 percent moderate; 24 percent severe), compared with 79 percent at major markets. This indicates that washing or cleaning is not routinely undertaken between farm gate and point of sale.

Table 2: Prevalence of defects in tracked tubers at market arrival

Defect Category	Specific Defect	Tubers (%)		
		Slight/Moderate	Severe	Total Affected
Agronomic & physiological	Growth cracks	8.1	0.4	8.4
	Greening	8.9	1.0	9.9
	Sprouting	5.6	0.1	5.7
	Internal discolouration	4.9	0.9	5.7
	Malformation	3.5	1.0	4.5
	Hollow heart	5.9	0.0	5.9
	Blackheart	-	0.6	0.6
Mechanical	Internal physical damage	9.9	1.1	11.0
	Feathering/skinning	40.1	10.3	50.3
	Cuts	15.4	5.1	20.5
	Bruising	13.9	3.3	17.2
Pathological	Pest damage (external)	8.1	0.9	8.9
	Pest damage (internal)	3.4	0.9	4.3
	Disease damage (external)	5.9	0.4	6.2
	Disease damage (internal)	4.3	0.7	5.0
	Rotting (external)	4.4	0.4	4.8
	Rotting (Internal)	3.4	1.0	4.4
Cosmetic & grading	Misshapen tubers	8.9	3.4	12.3
	Small tubers	-	35.3	35.3
	Dirty tubers	59.1	23.9	83.0
	Shriveled/flabby tubers	-	0.6	0.6
	Immature tubers	-	28.5	28.5

Notes: (1) Number of observations = 39 Total Percentages represent the sum of slight/moderate and severe defects as recorded in the assessment. (2) Slight or moderate defects reduce value but still allow the tuber to be sold, whereas severe defects render it unmarketable.

Source: Authors' computation from the Kenya potato quality assessment data (2025).

[7] See Appendix C: While tuber-level bruising prevalence remains comparable, trader exposure (82 percent) doubles farmer experience (40 percent)

Grading-related defects were also widespread. Small tubers (<50 mm) accounted for 35 percent of tubers in tracked consignments compared with 25 percent at major markets. The persistence of undersized tubers across market channels confirms that sorting interventions are not occurring at any point in the aggregation and distribution system. Shriveled or flabby tubers remained low at 0.6 percent, suggesting limited moisture loss during the relatively short transport and marketing period.

Agronomic, physiological, and pathological defects persisted throughout the supply chain, with prevalence rates in tracked loads confirming a lack of culling between the farm gate and market. Greening (9.9 percent) and growth cracks (8.4 percent) were more prevalent than in major markets, while hollow heart (5.9 percent) was more than double the market rate. Pathological damage levels also mirrored market observations, with external pest damage at 8.9 percent and external disease at 6.2 percent. Rotting levels were also consistent (4.8 percent external), and internal pest damage remained at 4.3 percent.

The consistency between tracked load pathological defect profiles and market observations provides strong evidence that diseased and pest-damaged produce moves through distribution channels with minimal quality-based culling. This pattern reflects the absence of enforced quality standards, limited economic incentives for sorting, and perhaps acceptance by both traders and consumers of defect levels that would be unacceptable in more formalized market systems.

The close alignment between tracked and market profiles, especially for pest damage, disease symptoms, and rots, points to the unfiltered flow of defective produce throughout the value chain. This result reflects persistent structural failures in quality governance and economic incentives. Taken together, these findings portray a value chain in which post-harvest practices do little to correct or filter farm-level quality problems, and in which the absence of effective quality standards or incentives leads to bulk movement of mixed-quality produce. As a result, the economic burden of handling-related losses is effectively transferred downstream: traders receive consignments already carrying a substantial load of damage and must absorb additional sorting costs and price discounts at the point of sale. Overall, this leads to compressed trader margins and higher prices for consumers to cover potential trader losses. Also, consumer acceptance of inferior produce ultimately hampers innovation in varietal selection and storage infrastructure.

5 QUALITY AT THE MARKET

5.1 Overview of market quality

The market assessment provides a snapshot of the potato quality at the end point of transaction in the value chain. Potato assessment at this stage follows post-harvest impacts, so that any flaws found in the market are a result of both inherent farm-gate issues as well as cumulative damage from handling, transportation, and storage practices. The compounded effects of these stages are likely to lower marketability and render the product more vulnerable to additional losses during distribution, such as increased rotting.

Compared to the farm gate, the market assessment revealed a clear increase in the prevalence of key tuber defects. It is important to note that even modest average percentages can cause substantial absolute losses at scale, leading to supply-chain inefficiencies like higher rejection rates and depressed prices.

5.2 Profile of tuber defects at market

The profile of defects at the market level mirrors the farm gate. The assessment reveals that quality issues not only persist, but in several categories, intensify as potatoes move along the value chain. Table 3 outlines the prevalence of defects observed among 54 traders.

At this stage, there is a prominent shift toward mechanical and cosmetic defects, particularly those related to handling and skin integrity. Overall, the findings highlight that while many potatoes suffer from minor bruising or cuts that allow them to remain in the trade cycle, the high frequency of these issues across most market participants indicates systemic handling challenges. The data compares the total percentage of the potato supply that is damaged against the percentage of commercial sellers encountering these defects, illustrating that even if the volume of severely damaged stock is low, most traders must manage lots containing at least some level of defective produce.

Table 3: Prevalence of primary tuber defects at market level

Defect Category	Specific Defect	Tubers (%)			Traders (%)		
		Slight/ Moderate	Severe	Total Affected	Slight/ Moderate	Severe	Total Affected
Agronomic & physiological	Growth cracks	5.7	0.2	5.9	61.1	3.7	61.1
	Greening	5.2	0.5	5.7	57.4	9.3	57.4
	Sprouting	3.7	0.0	3.7	25.9	0.0	25.9
	Internal ciscolouration	4.4	0.4	4.8	51.9	3.7	55.6
	Malformation	7.2	1.2	8.4	59.3	13.0	59.3
	Hollow heart	2.2	0.4	2.6	13.0	5.6	16.7
	Blackheart	-	0.2	0.2	-	3.7	3.7
Mechanical	Internal physical damage	5.6	1.5	7.1	59.3	18.5	64.8
	Feathering/skinning	30.0	8.6	38.5	83.3	22.2	83.3
	Cuts	13.4	4.3	17.7	94.4	42.6	96.3
	Bruising	14.8	1.2	16.1	77.8	13.0	81.5
Pathological	Pest damage (external)	7.9	1.3	9.3	64.8	9.3	66.7
	Pest damage (internal)	3.7	0.3	4.0	48.2	3.7	48.2
	Disease damage (external)	2.9	0.7	3.6	38.9	9.3	42.6
	Disease damage (internal)	4.2	0.8	5.0	42.6	13.0	46.3
	Rotting (external)	4.3	0.7	5.0	53.7	9.3	53.7
	Rotting (internal)	2.3	0.8	3.1	37.0	11.1	37.0
Cosmetic & grading	Misshapen tubers	13.7	3.8	17.5	66.7	27.8	70.4
	Small tubers	-	25.4	25.4	-	96.3	96.3
	Dirty tubers	42.0	37.3	79.3	85.2	48.2	98.2
	Shriveled/flabby tubers	-	0.6	0.6	-	7.4	7.4
	Immature tubers	-	11.7	11.7	-	42.6	42.6

Notes: (1) Number of observations = 54 Total Percentages represent the sum of slight/moderate and severe defects as recorded in the assessment. (2) Slight or moderate defects reduce value but still allow the tuber to be sold, whereas severe defects render it unmarketable.

***Source**: Authors' computation from the Kenya potato quality assessment data (2025).*

The largest deterioration in quality between the farm and the market was observed in mechanical damage, which can show as skin abrasions, bruising, or more severe internal injuries (Yadav & Singh, 2021). Results indicate that feathering or skin abrasions more than doubled, rising from 15 percent at the farm gate to 39 percent at the market[8]. This high rate of skinning points to inadequate protection during transit, where tubers rub against each other or surfaces.

Closely related to this are bruising (16 percent), cuts (18 percent), and internal physical damage (7 percent). While feathering was the most common defect by volume, cuts were the most widespread issue with 96 percent of traders selling stock containing cut tubers, compared to 76 percent of farmers. The combination of these mechanical defects results in the immediate compromise of the tuber's protective skin layer, allowing pathogens to enter the tuber through bruises, wounds, or cuts. This renders the crop highly vulnerable to secondary rot and moisture loss during market display (Misener et al., 1988).

Agronomic defects, while often less severe than mechanical damage, present significant challenges in potato markets. The prevalence of these issues is shaped by a combination of the production system, potato variety, and post-harvest handling. For instance, adverse weather during the growing season can lead to physiological disorders like greening and cracking, while inadequate storage and transport practices can exacerbate the spread of disease (Zarzyńska and Boguszewska-Mańkowska, 2024).

Generally, physiological defects can reveal storage management challenges and harvest timing concerns. Among the most common physiological disorders are growth cracks and greening, which affect 5.9 percent and 5.7 percent of tubers at the market level, respectively. Growth cracks, often resulting from environmental stress or varietal susceptibility, reduce the visual appeal and storability of potatoes. Research shows that higher concentrations of tuber dry matter, starch, and calcium can confer greater resistance to cracking (Koch et al., 2019). Both defects increase waste during processing and heighten the risk of subsequent pathogen infection (Zarzyńska and Boguszewska-Mańkowska, 2024). Other observed physiological defects include tuber malformation that affects 59 percent of traders and 8.4 percent of tubers, and hollow heart that affects 17 percent of traders and 2.6 percent of tubers. On the other hand, blackheart is observed in only 0.2 percent of tubers but affects 3.7 percent of traders.

Pathological damage from pests and diseases is another prominent concern, and these issues often worsen significantly during the post-harvest period. The delay between harvest and market sales allows latent infections and pest damage to become more pronounced, leading to increased visible defects. For example, external rotting increases more than threefold, from 1.5 percent at the farm gate to 5 percent at the market. This is likely a secondary effect of mechanical damage, as cuts and skinned areas provide entry points for pathogens that develop into rot during transport and storage. Similarly, external pest damage rises from 5.4 percent to 9.3 percent along the supply chain. This result signals that damaged tubers are not being correctly filtered out at the farm gate, which effectively concentrates the defect as it moves to market. Ultimately, these exterior flaws that manifest as surface holes, necrotic spots, and internal decay, significantly reduce the commercial quality of potatoes, forcing traders to accept lower prices or discard the affected produce entirely, thereby impacting overall marketability and profitability (Osawa et al., 2018; Zarzyńska and Boguszewska-Mańkowska, 2024).

The comparison of cosmetic defects between the farmgate and market reveals limited cleaning between harvest and sale. The prevalence of dirty tubers, for instance, remained nearly unchanged, affecting 81 percent of produce at the farm and 79 percent at the market. This minimal change confirms that no cleaning or washing takes place before the produce reaches the trader. In particular, the high prevalence of dirty tubers at both the farm gate and markets reflects a deliberate local practice among smallholder farmers rather than a lack of hygiene. Farmers typically avoid washing potatoes because the adhering soil serves as a protective layer that cushions tubers against mechanical damage during the rough logistics phase. Furthermore, many low resource-constrained farmers fail to wash tubers due to scarcity of

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[8] See Appendix C: Traders reported substantially higher exposure to skinned tubers (83 percent) compared to farmers (50 percent).

water during harvesting period -usually the dry season-, cost of additional labor and possible tuber spoilage when not dried on time (Oshunsanya, 2016), exposing tubers to a higher risk of bruising and rapid rotting during handling. Consequently, the prevailing market dynamics do not reward washed produce; instead, the value chain accepts potatoes in their natural, unwashed form as a fresh, immediately marketed crop.

Similarly, grading practices remain inadequate despite representing a critical value-addition opportunity within the potato value chain. Current grading protocols classify tubers based on size and shape, with potatoes below 50mm ranked as small grade (NPCK, 2021). At the market level, small tubers accounted for 25 percent of the sample, suggesting that farmers are not sorting their harvest effectively and traders are accepting unsorted bags containing a significant proportion of low-value, undersized produce. Additionally, the prevalence of immature tubers rose from 5.5 percent at the farm to 12 percent at the market, indicating that immature crops are not being filtered out. This finding may reflect gaps in farmer agronomic knowledge, such as optimal harvest timing, or a tendency to harvest prematurely to meet immediate food and cash demand. Poor grading, or the mixing of grades due to bulk assessment of marketable produce, erodes the bargaining power of both farmers and traders, ultimately leading to lower prices (economic losses) and reduced incomes. Appendix C illustrates these patterns with confidence intervals showing the variability in defect prevalence between farm gate and market stages.

The defect profile at the market level reveals notable limitations in the potato value chain. While the farm establishes the initial quality baseline, the post-harvest value chain imposed considerable and preventable damage to that quality, primarily through physical or handling damage. Vulnerabilities originating at the farm gate are compounded by post-harvest processes, leading to increased quality deterioration. This consequently contributes to heightened economic losses due to product rejection and reduced pricing, which in turn constrain the sustainability of small-scale farming and trading operations.

The findings suggest the need for the extension of targeted strategies, such as strengthened adherence to handling protocols, adoption of essential technologies including cleaning equipment, and collaborative training initiatives to address knowledge deficiencies. In the absence of these interventions, the value chain may continue to experience suboptimal performance and forgone opportunities for efficiency and competitiveness. By contrast, their implementation could help reduce post-harvest waste, increase profitability, and strengthen the overall potato industry.

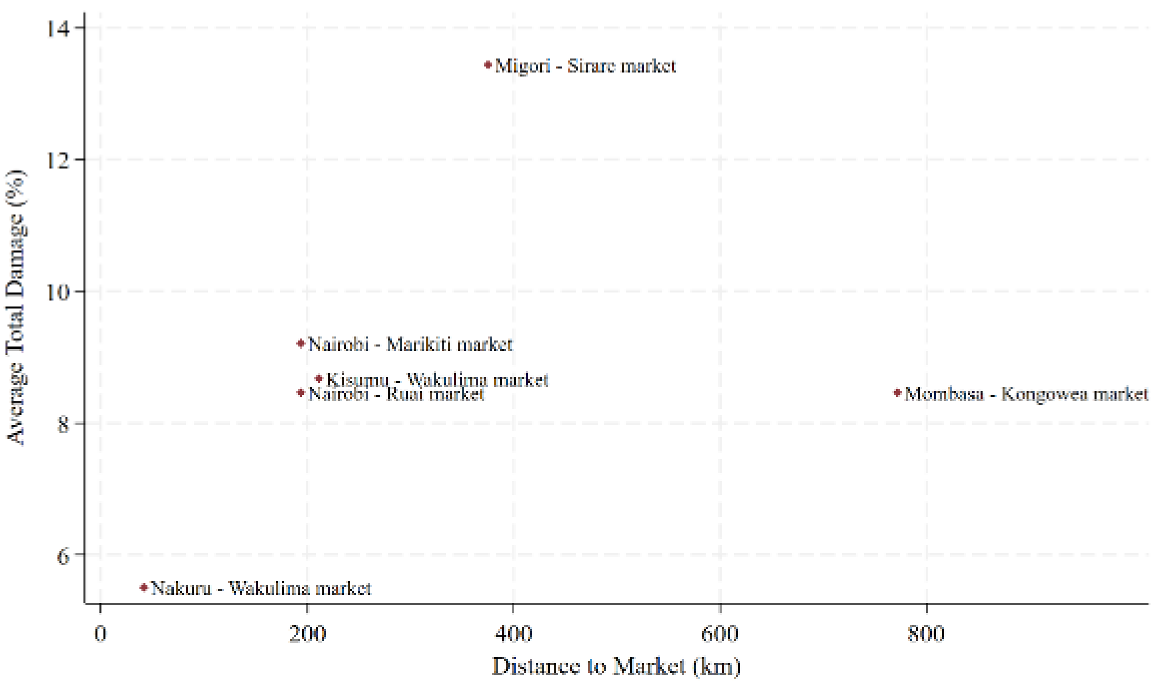
5.3 Inter-market comparison

This section explores if supply chain length/destination impacts quality. The selection of markets, ranging from local hubs (Wakulima-Nakuru) to distant terminals (Kongowea-Mombasa), was designed to capture the effect of supply chain length on potato qualitative degradation. Potential variation in market quality is likely a function of the number of times the consignment is handled and the duration of the journey, which allows for the progression of rot in already damaged tubers. Furthermore, it is a well-established principle in post-harvest logistics that longer transit times and multiple handling points inherently increase the risk of damage and deterioration (Kaur and Watson, 2024).

Figure 2 illustrates the relationship between market distance from the point of origin -Kenya's main potato production hubs (Nakuru and Nyandarua)- and average total potato damage at each market. The scatter plot reveals a weak positive relationship between distance and damage levels. Markets closer to Nakuru and Nyandarua, such as Nakuru-Wakulima, exhibit the lowest average damage at 5.5 percent, while more distant markets, such as Mombasa-Kongowea, show higher damage at 8.5 percent. This pattern aligns with expectations, as longer transport distances increase the risk of mechanical damage, spoilage, and quality deterioration during transit. Markets at intermediate distances (150–350 km), including Nairobi-Marikiti, Kisumu-Wakulima, and Nairobi-Ruai, cluster around 8–9 percent damage, indicating relatively consistent loss levels within this range.

However, distance alone is not the sole determinant of damage. A notable outlier is the Sirare market in Migori, located approximately 375 kilometers from the production hubs, that exhibits the highest average damage at 13 percent. This percentage suggests that other factors, such as road conditions, handling practices, and storage infrastructure, are also potential contributors to quality and post-harvest losses. The variability among markets at similar distances further underscores that while proximity to production hubs is an advantage, the final quality of produce is heavily influenced by local handling capacity and infrastructure. These findings indicate that targeted interventions, such as improved packaging, ventilated or refrigerated transport, and better handling at the market level, are critical for reducing losses, especially in long-distance supply chains.

Figure 2: Relationship between potato damage at markets and distance from Nakuru–Nyandarua production areas

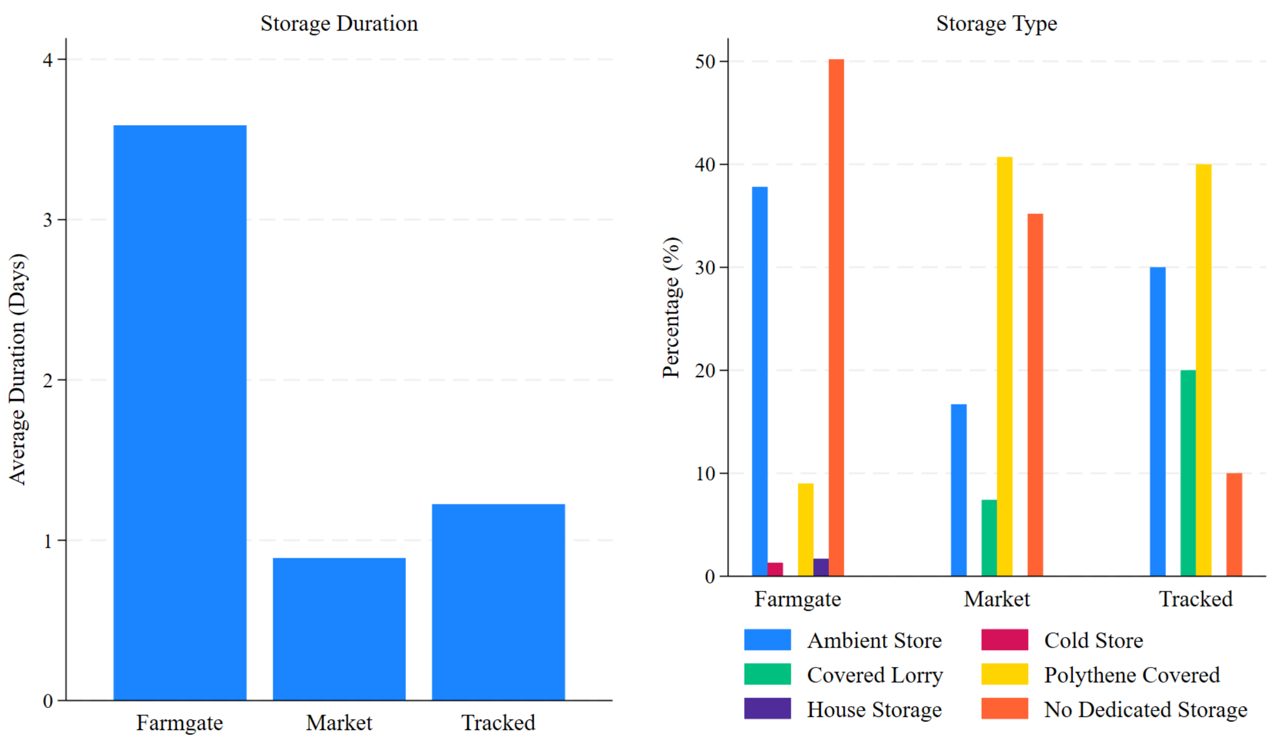


Source: Authors' own computation from the potato quality assessment data (2025).

6 STORAGE CONDITIONS ACROSS THE VALUE CHAIN

The storage methods employed at different stages of the value chain reveal a systemic reliance on rudimentary, low-cost preservation techniques that offer minimal protection against quality degradation. Figure 3 depicts how long and in what conditions potatoes are stored at each node of the value chain. Approximately 35 percent of all traders had no dedicated storage method, leaving their produce completely exposed to environmental factors. Tubers are temporarily piled on the ground in open-air. This mirrors the pattern observed at the farm gate (50 percent) and suggests a business model based on rapid turnover rather than quality preservation. Another 41 percent of traders rely solely on basic polythene covering - essentially plastic sheeting - which provides only superficial protection against moisture and contamination. Ambient storage facilities account for 17 percent of usage, while more sophisticated options remain virtually absent from the trading landscape, with cold storage adoption falling below detectable levels.

Figure 3: Storage practices across the potato value chain



Source: Authors' own computation from the potato quality assessment data (2025).

In the transit (tracked) phase, polythene covering remains the dominant method at approximately 40 percent, likely serving as makeshift protection for loads transported in open vehicles. Covered lorries, which provide better protection during transit, are utilized in 20 percent of cases, reflecting the specific needs of transportation. As expected, transporters show lower rates of completely unprotected storage (10 percent) compared to traders, suggesting some recognition of quality risks during movement. Cold storage remains virtually non-existent. This distribution underscores a sector-wide dependence on low-cost, low-technology solutions that offer minimal protection against the primary drivers of post-harvest loss: heat, humidity, and pest infestation.

These storage patterns reveal systemic vulnerabilities that are compounded across the supply chain. The farm gate emerges as a loss hotspot, where the combination of extended storage duration (averaging 3.6 days) and predominant reliance on ambient conditions or no storage at all (88 percent combined) creates a perfect storm for quality degradation. Under these conditions, perishable produce such as potato tubers can experience post-harvest losses due to accelerated microbial growth, dehydration, and physiological deterioration. This vulnerability is particularly acute because smallholder farmers, who dominate production, face significant economic and infrastructural barriers to accessing better storage technologies.

At the market level, the paradox of efficient turnover versus quality preservation becomes apparent. While the short average storage duration of 0.9 days suggests rapid sales and minimal holding periods, the heavy reliance on no storage or basic polythene covering (76 percent combined) exposes produce to numerous market-specific hazards including dust contamination, insect damage, and extreme temperature fluctuations. This high-turnover model functions adequately under normal conditions but becomes problematic when market dynamics shift. Any disruption that extends holding periods—whether from oversupply, reduced demand, or logistical delays—can trigger cascading quality losses in the absence of proper storage infrastructure.

The transportation segment, despite showing marginally better adaptation with its 1.2-day average duration and some use of covered vehicles, still reflects missed opportunities for quality maintenance. The diversity of methods employed suggests that transporters are constrained by available resources rather than making optimal choices. The persistent absence of cold chain infrastructure during movement is particularly concerning given that cumulative damage during transit, especially in hot climates or over long distances, can considerably erode the value captured at harvest. Perhaps more important is the near-universal underutilization of cold storage across all value chain stages, with adoption rates consistently below 2 percent. This value represents a fundamental market failure given that cold storage can significantly extend shelf life and reduce quality loss by slowing sprouting, microbial growth, and physiological degradation for many horticultural products including potatoes (Palle et al., 2024).

The barriers to adoption likely encompass multiple dimensions: prohibitive capital costs, unreliable electricity supply, lack of technical knowledge, and possibly inadequate market incentives that fail to reward quality preservation through price premiums. This systemic underinvestment in cold chain infrastructure perpetuates a vicious cycle of high post-harvest losses, price volatility, and food insecurity that disproportionately impacts smallholder farmers and rural communities who lack the resources to absorb these inefficiencies.

7 CONCLUSION

This qualitative study provides an analysis of potato tuber quality across key nodes in Kenya's potato value chain, revealing systemic vulnerabilities that contribute to substantial post-harvest losses estimated at 30–40 percent (NPCK, 2025). By establishing baselines at the farm gate, assessing endpoints at major markets, and tracking consignments, the findings highlight how intrinsic farm level defects are compounded by post-harvest handling, leading to amplified degradation at markets.

For example, while the study established that 15 percent of tubers already suffer from skin abrasions at the farm level due to premature harvest, the subsequent degradation during transit is severe. Mechanical damage more than double the time produce reaches the market, with skinning rising to 39 percent. This indicates that the current logistics and handling systems are active contributors to quality loss. The tracked shipments corroborate this finding, showing minimal culling of defective produce during transit operations.

The logic underpinning these quality losses aligns with established challenges in the Kenyan potato subsector: a fragmented marketing system dominated by unregulated middlemen, limited access to high quality inputs, and insufficient infrastructure (Kaguongo et al., 2014; Maingi et al., 2015). Additionally, the persistence of defects across the value chain signals a profound lack of market signaling. In a functioning market, price premiums for sorted, clean produce would drive behavior change. The absence of this sorting suggests an information asymmetry where traders accept bags of mixed potato quality, ultimately reducing prices for all actors.

Our analysis shows that the potato value chain operates with substantial inefficiencies that impose quality and economic penalties on smallholder producers. The documented quality degradation, from relatively manageable farm-gate defect levels to the substantially compromised produce observed at terminal markets, represents preventable waste arising from information gaps, coordination failures, and inadequate quality governance.

These systemic challenges are exemplified by the structure of transport and logistics of potato shipment across the chain. Findings from the digital tools baseline survey (Boukaka et al., 2025) reveal a significant disconnect between producers and the supply chain as 95 percent to 98 percent of farmers sell directly at the farm gate and relinquish control thereafter. Consequently, the logistics phase is dominated by brokers and traders, who serve as the primary link to markets. Up to 65 percent of farmers sell to brokers and up to 53 percent transact directly with traders (Boukaka et al., 2025), who often oversee transport to markets. Despite using open trucks, brokers who are usually the transporters show much higher awareness of quality risks than traders, with only 10 percent of the tracked consignment left completely unprotected compared to over 30 percent of traders at the market level who have no dedicated storage.

Three overarching conclusions emerge from the analysis. First, quality loss is primarily a coordination problem rather than solely a technical challenge. While infrastructure deficits (inadequate storage, poor road conditions) contribute to losses, the study reveals that even existing rudimentary infrastructure could deliver better outcomes with improved coordination. The 3.6-day average farm-gate storage duration, the unfiltered movement of defective produce through the supply chain, and the near-complete absence of washing or grading interventions all point to coordination failures that FSCs and digital platforms could potentially address. FSCs act as essential bridges between farmers and the market by providing access to quality inputs (seeds and fertilizers) and information. The BDEC (Business Development and Coaching) program specifically trains FSCs to improve their service delivery, including negotiation skills (62 percent of BDEC-trained vs. 40 percent non-BDEC) and coaching/mentoring (Boukaka et al., 2025). Given that some FSCs also offer aggregation services, they can employ digital tools to assist in logistics, particularly harvest coordination, and market access.

Second, the value chain displays ineffective quality-based market signals. The persistence of identical defect profiles from tracked loads to market sales confirms that current market structures provide insufficient incentives for quality sorting, preservation, or value addition. However, we acknowledge this could differ depending on the structure of the markets and final buyer. For example, major consumer markets such as Marikiti and Kongowea that are trade centered on table varieties like *Shangi*, often provides insufficient incentives for sorting, while processing sector buyers demonstrate robust signaling based on tuber size. In processing channels, larger tubers (typically those exceeding 50mm or 60mm in diameter) command distinct price premiums over smaller sizes. However, major consumer-oriented market channels do not yet fully reward size-based sorting, pointing to a structural divide in how quality based signals are transmitted depending on the nature of the market. Without price premiums for superior quality or penalties for defective produce, rational actors have little motivation to invest in quality-preserving practices. Digital grading systems and tiered pricing mechanisms could create the market differentiation necessary to reward quality investment.

Third, the storage infrastructure gap represents both a great vulnerability and an actionable intervention opportunity. The widespread reliance on no storage or basic polythene covering (88 percent combined at farm gate; 76 percent at market) creates multiple quality loss hotspots. However, the relatively short holding periods (3.6 days at farm, 0.9 days at market, 1.2 days in transit) suggest that targeted interventions -reducing exposure time or improving ambient storage management- could yield substantial returns without requiring transformative infrastructure investment.

The physical defects identified (cuts, bruises, rots) are symptoms of decision-making failures, such as harvesting too early, packing in non-breathable bags, and transporting in open trucks, all aspects that digital tools are uniquely positioned to address. By bridging knowledge gaps and connecting fragmented market actors, digital platforms can move the sector from a push-system (farmers selling everything they harvest) to a pull-system (buyers demanding specific quality standards via digital contracts). Furthermore, farm-level data indicating a 76 percent incidence of mechanical damage, particularly tuber cuts, underscores the critical necessity of continued deployment of Harvesting Service Providers trained in better techniques.

Digital agricultural tools can serve as powerful catalysts for value chain transformation by addressing information asymmetries and enabling real-time coordination. However, the digital tools baseline results reveal a large disconnect. While farmers heavily rely on financial and communication apps such as M-PESA and WhatsApp, only 5 percent utilize agriculture-specific platforms like Hello Tractor or Viazi Soko (Boukaka et al., 2025). To bridge this gap and unlock value currently lost to inefficiencies, the BDEC program positions FSCs as technology hubs that are directly accessible to producers. In addition to already existing BDEC digital applications, we recommend expanding the digital portfolio to include supply chain solutions, agronomic advisors, and integrated platforms to facilitate input access and credit. Increasing the uptake of these tools is essential to strengthen farmer-buyer linkages, improve advisory services, and create digital incentives for cold storage adoption.

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APPPENDIX

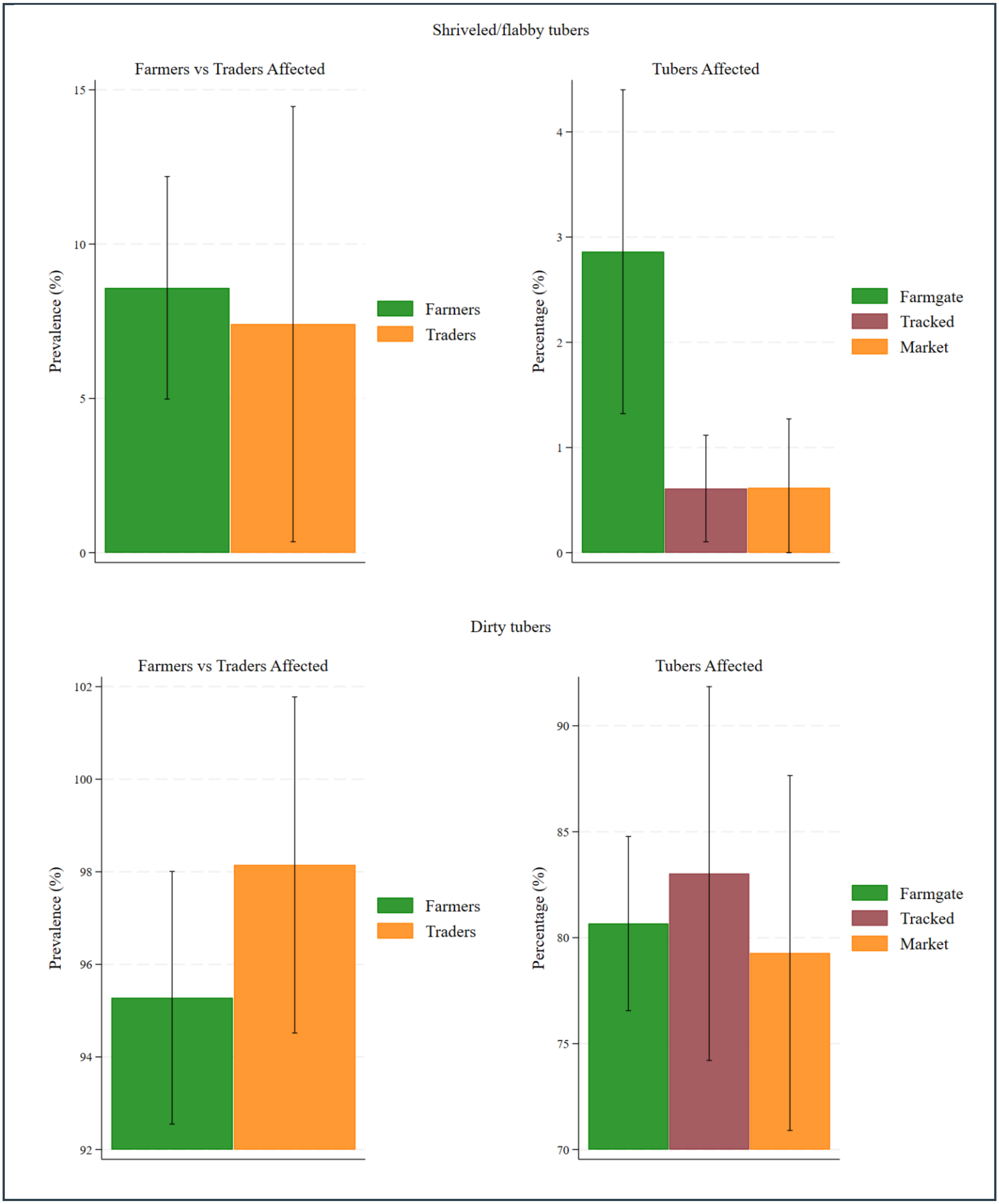
Appendix A: Glossary of Terms and Defect Definitions

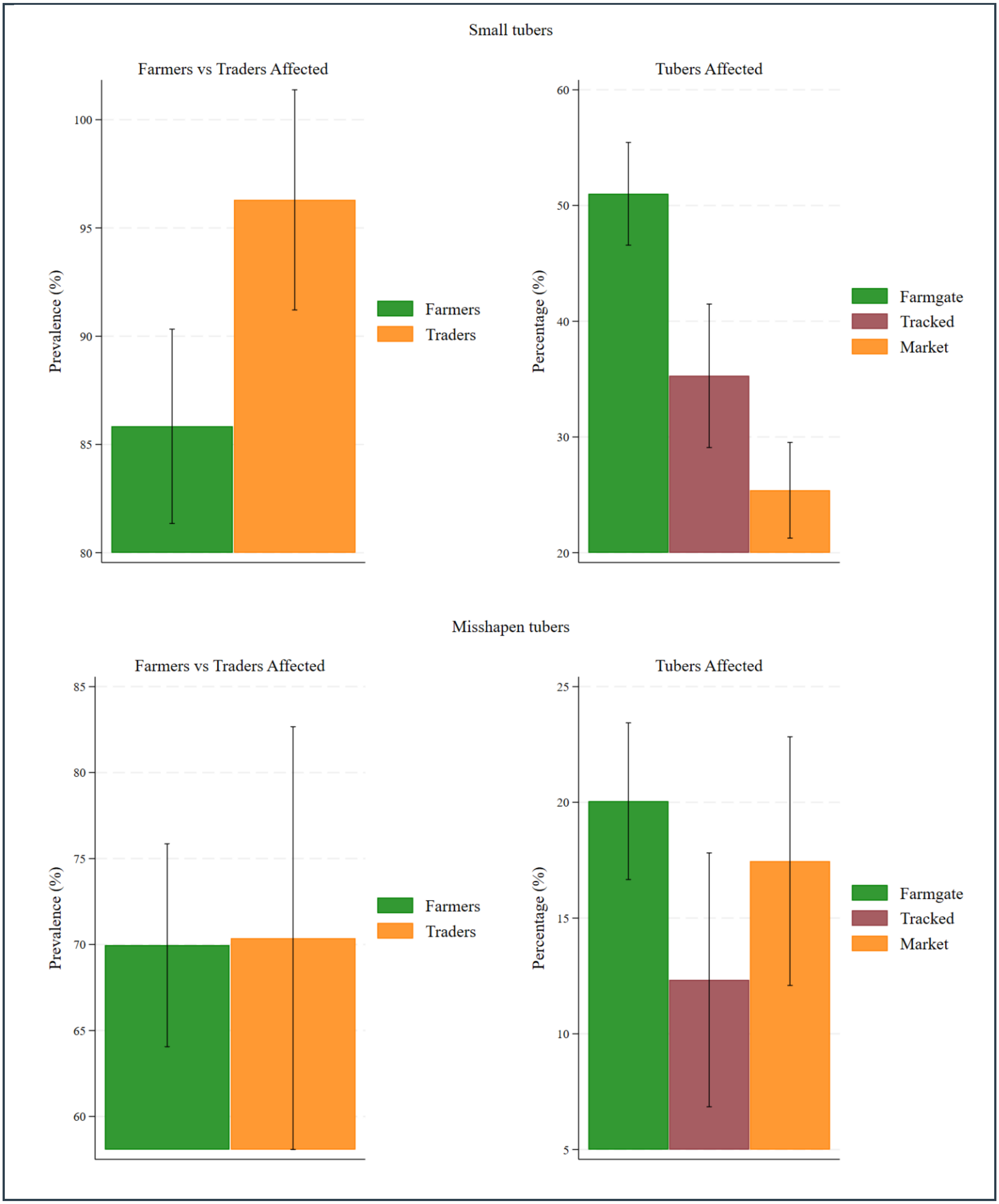
Term	Category	Definition
Feathering (Skinning)	Mechanical	A defect where the skin of the tuber is abraded or rubbed off. It is often caused by harvesting before the skin has matured (set).
Bruising	Mechanical	Subcutaneous damage resulting from impact or friction during handling. It often serves as an entry point for pathogens.
Cuts	Mechanical	Physical injuries caused by sharp tools (hoes/forks) or objects during transport.
Internal Physical Damage	Mechanical	Injuries to the tuber flesh not visible externally, identified only by cutting the tuber.
Greening	Physiological	Chlorophyll development beneath the skin due to light exposure. Indicates the presence of solanine (toxic).
Growth Cracks	Physiological	Physical splits in the tuber surface caused by environmental stress or inconsistent soil moisture.
Hollow Heart	Physiological	A star- or lens-shaped cavity in the center of the tuber caused by rapid, uneven growth.
Malformation (Misshapen)	Physiological	Tubers deviating from the normal varietal shape, linked to poor soil structure or moisture.
Late Blight	Pathological	A fungal disease manifesting as dark, sunken lesions on the tuber surface.
Potato Tuber Moth (PTM)	Pathological	Damage by larvae characterized by entry/exit holes and tunneling beneath the skin.
Rot	Pathological	Bacterial or fungal decay of tissue, often secondary to mechanical wounds.
Farm Gate	Supply Chain	The point of origin immediately post-harvest. Represents the quality ceiling.
Consignment Tracking	Methodology	A method where specific batches are tagged at the farm and reassessed at the market.

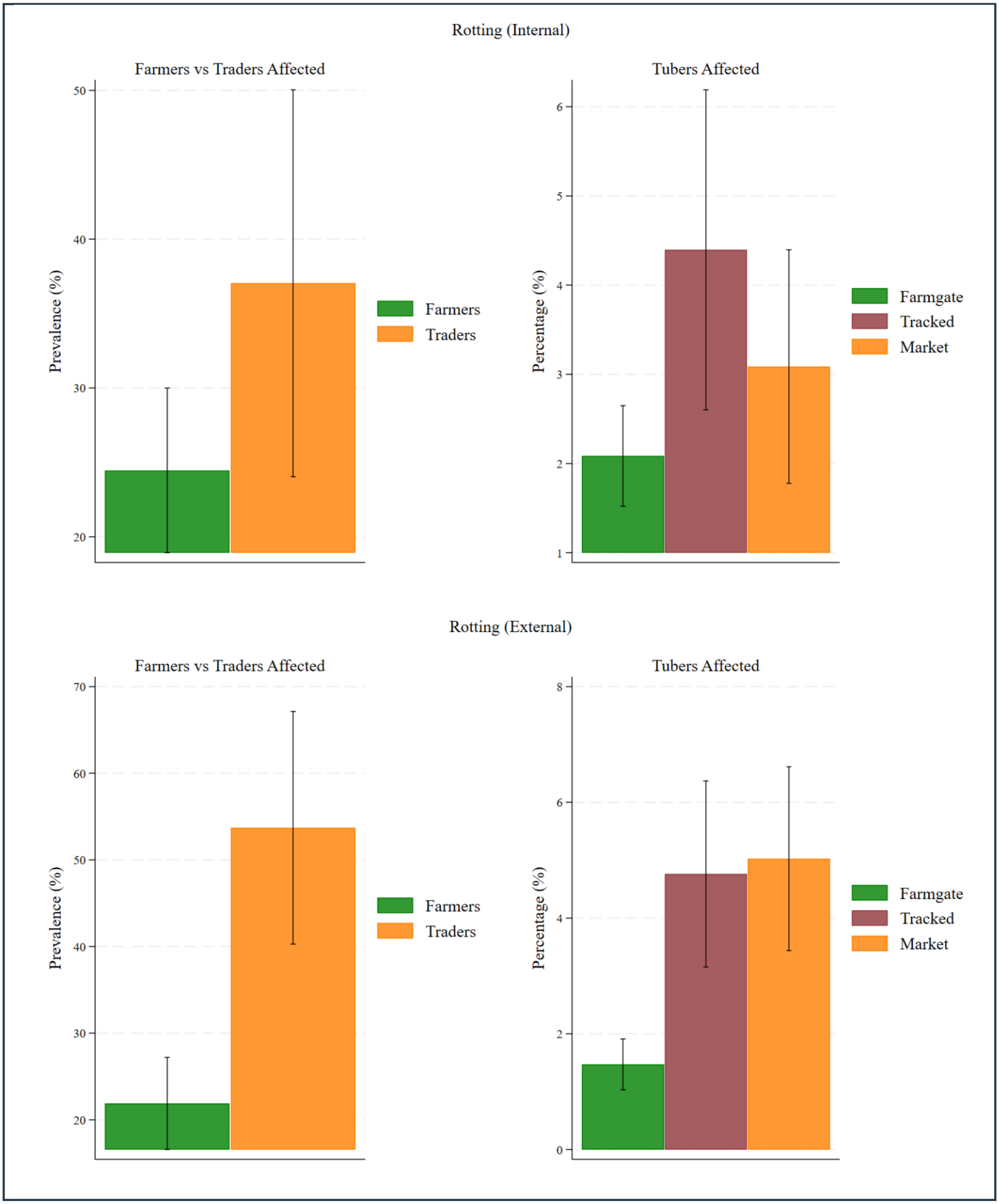
Appendix B: Market Study Site Characteristics

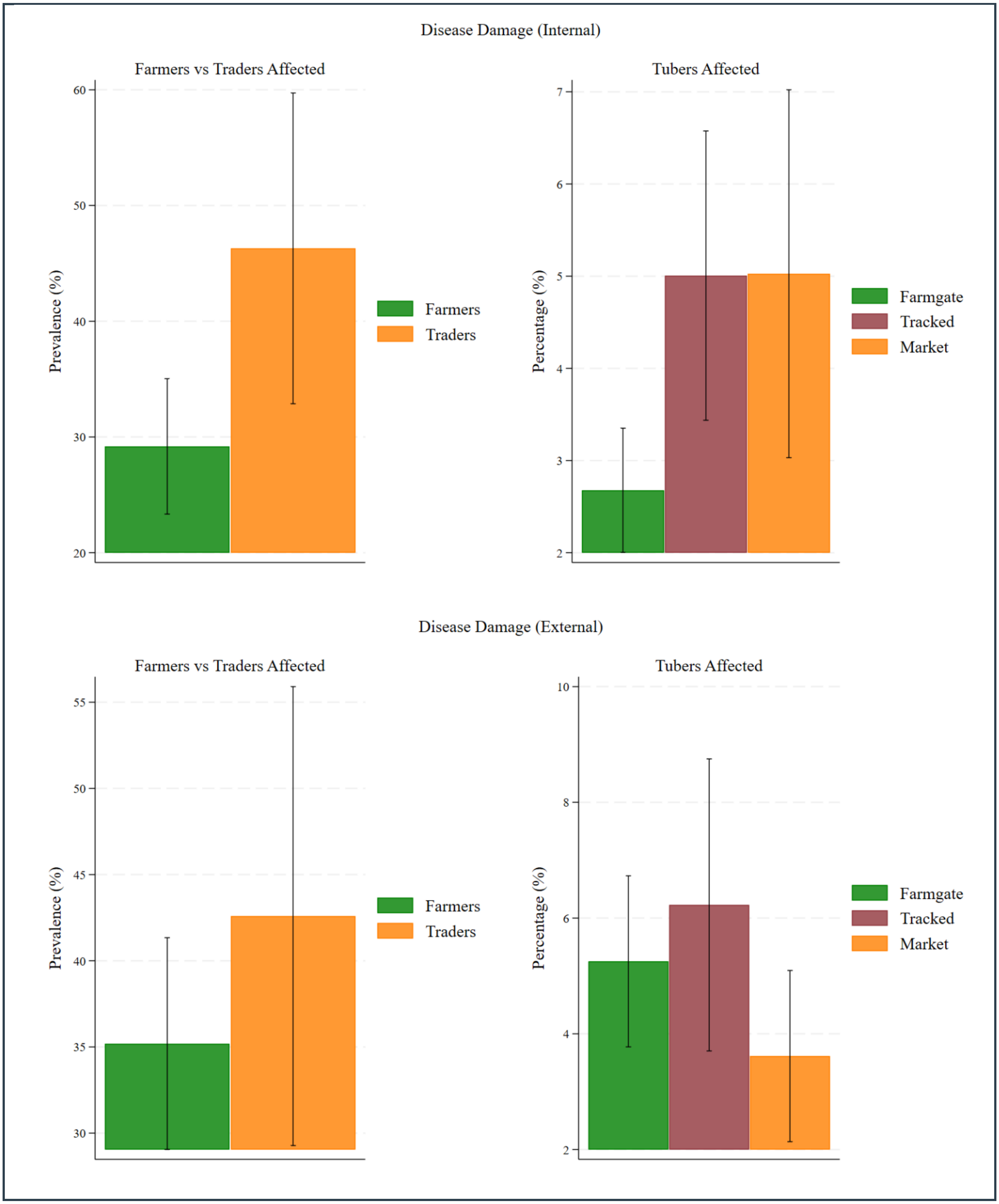
Market Name	Location	Role/ Classification	Key Logistics Characteristic
Wakulima	Nakuru	Regional Hub	Central collection point serving local consumption and redistribution.
Wakulima	Kisumu	Regional Hub	Western Kenya's primary distribution center serving cross-border trade routes.
Sirare	Migori	Border Market	Key border market for regional trade; exhibited the highest damage (13.4 percent).
Marikiti	Nairobi	Metropolitan Distribution	Represents the country's largest consumption center and wholesale network.
Ruai	Nairobi	Metropolitan Distribution	A dual assessment point in the capital city alongside Marikiti.
Kongowea	Mombasa	Coastal Terminal	Represents the longest transport distance from production areas.

Appendix C: Distribution of defects across the value chain

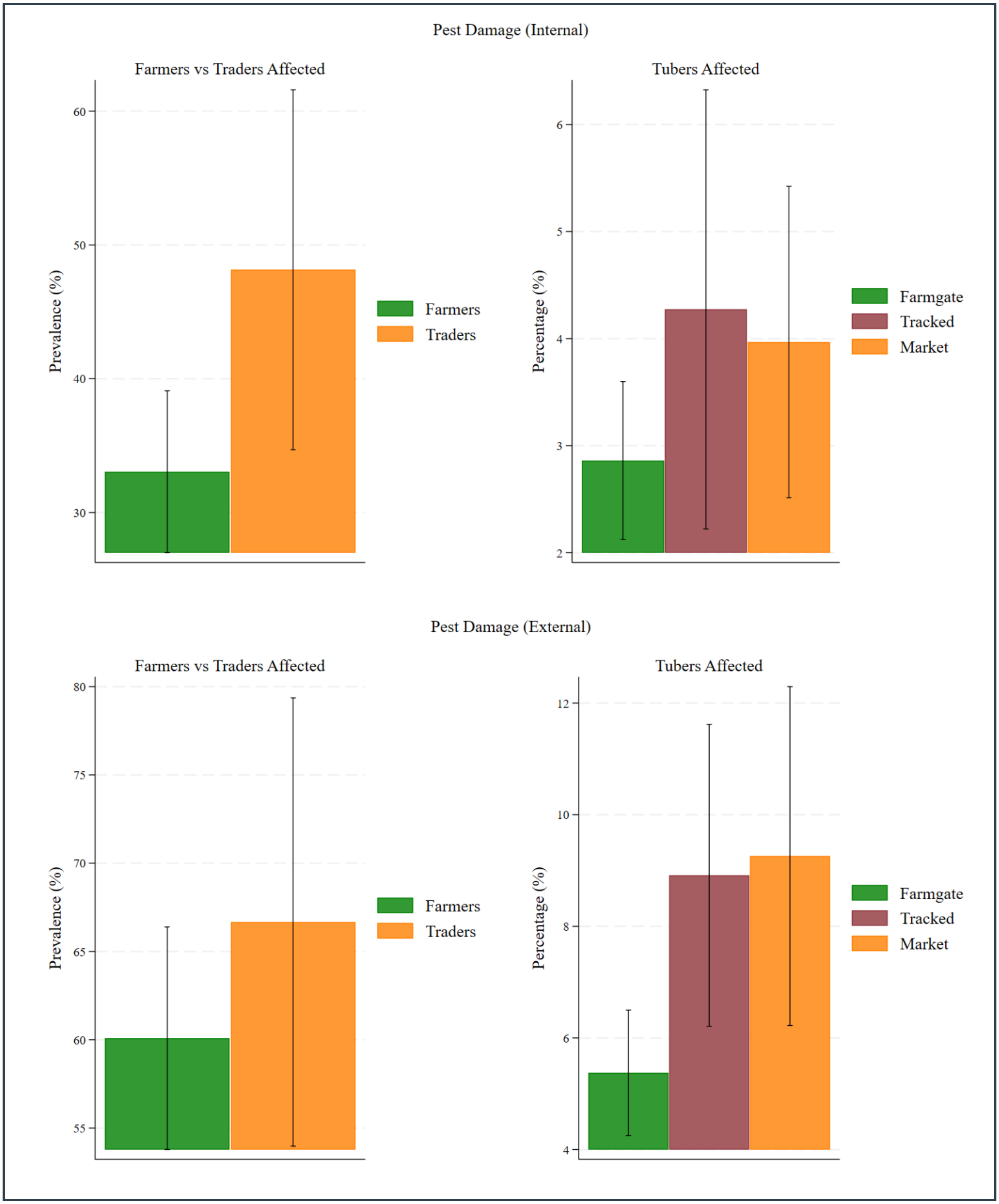



Small tubers
Farmers vs Traders Affected
Prevalence (%)
100
95
90
85
80
Farmers
Traders
Tubers Affected
Percentage (%)
60
50
40
30
20
Farmgate
Tracked
Market
Misshapen tubers
Farmers vs Traders Affected
Prevalence (%)
85
80
75
70
65
60
Farmers
Traders
Tubers Affected
Percentage (%)
25
20
15
10
5
Farmgate
Tracked
Market

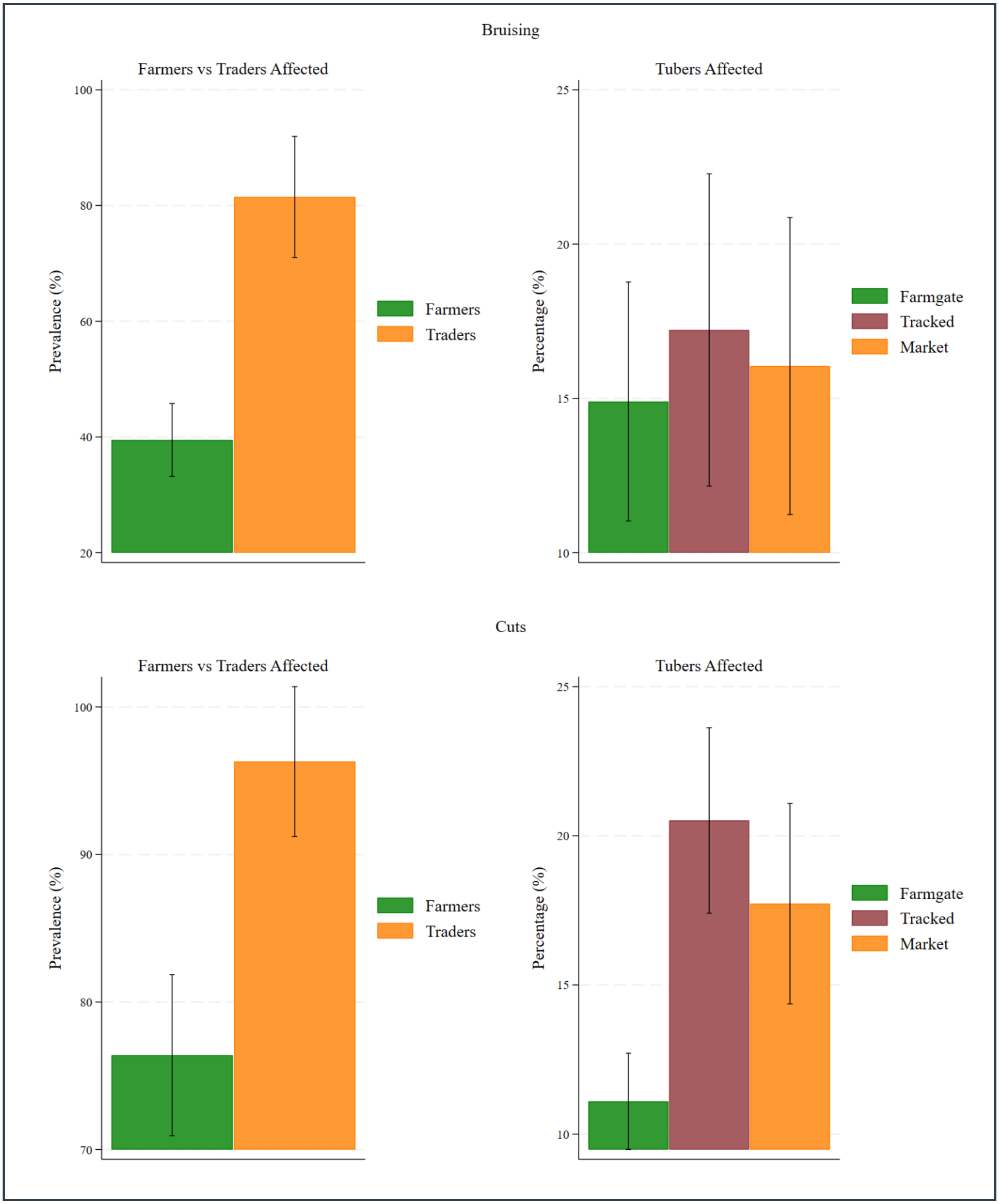

Rotting (Internal)
Farmers vs Traders Affected
Prevalence (%)
50
40
30
20
Farmers
Traders
Tubers Affected
Percentage (%)
6
5
4
3
2
1
Farmgate
Tracked
Market
Rotting (External)
Farmers vs Traders Affected
Prevalence (%)
70
60
50
40
30
20
Farmers
Traders
Tubers Affected
Percentage (%)
8
6
4
2
0
Farmgate
Tracked
Market

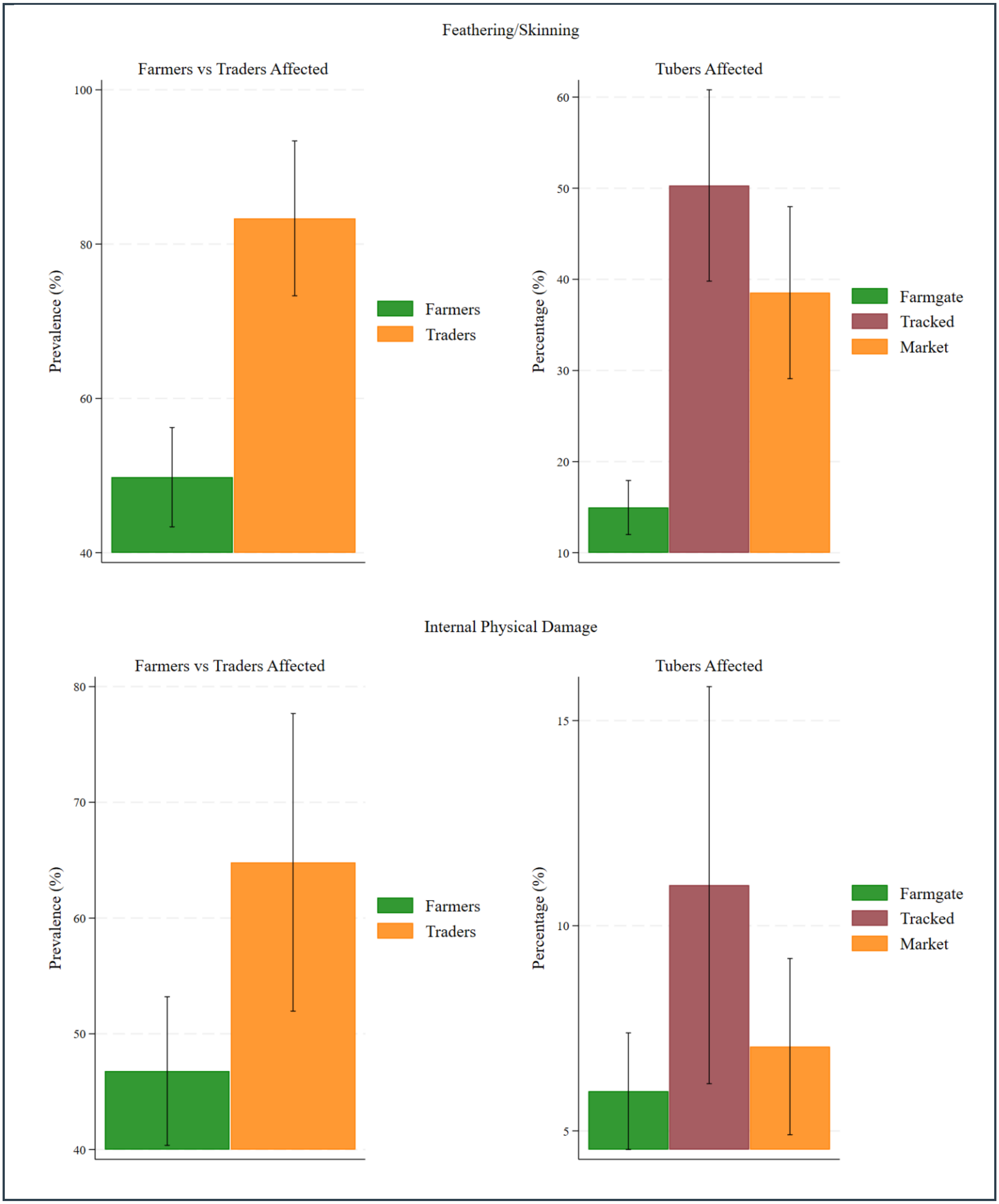


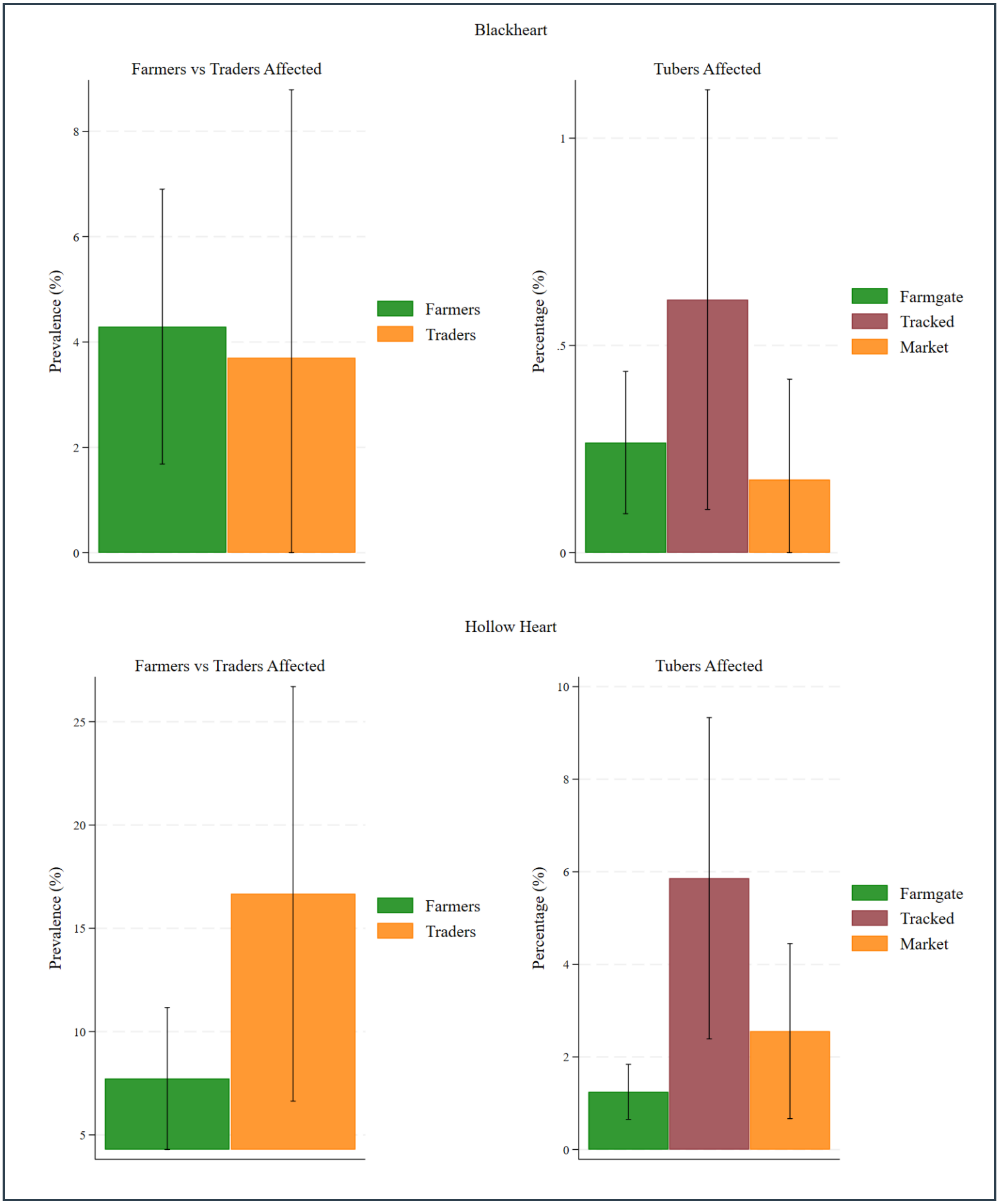
Disease Damage (Internal)
Farmers vs Traders Affected
Prevalence (%)
60
50
40
30
20
Farmers
Traders
Tubers Affected
Percentage (%)
7
6
5
4
3
2
Farmgate
Tracked
Market
Disease Damage (External)
Farmers vs Traders Affected
Prevalence (%)
55
50
45
40
35
30
Farmers
Traders
Tubers Affected
Percentage (%)
10
8
6
4
2
Farmgate
Tracked
Market



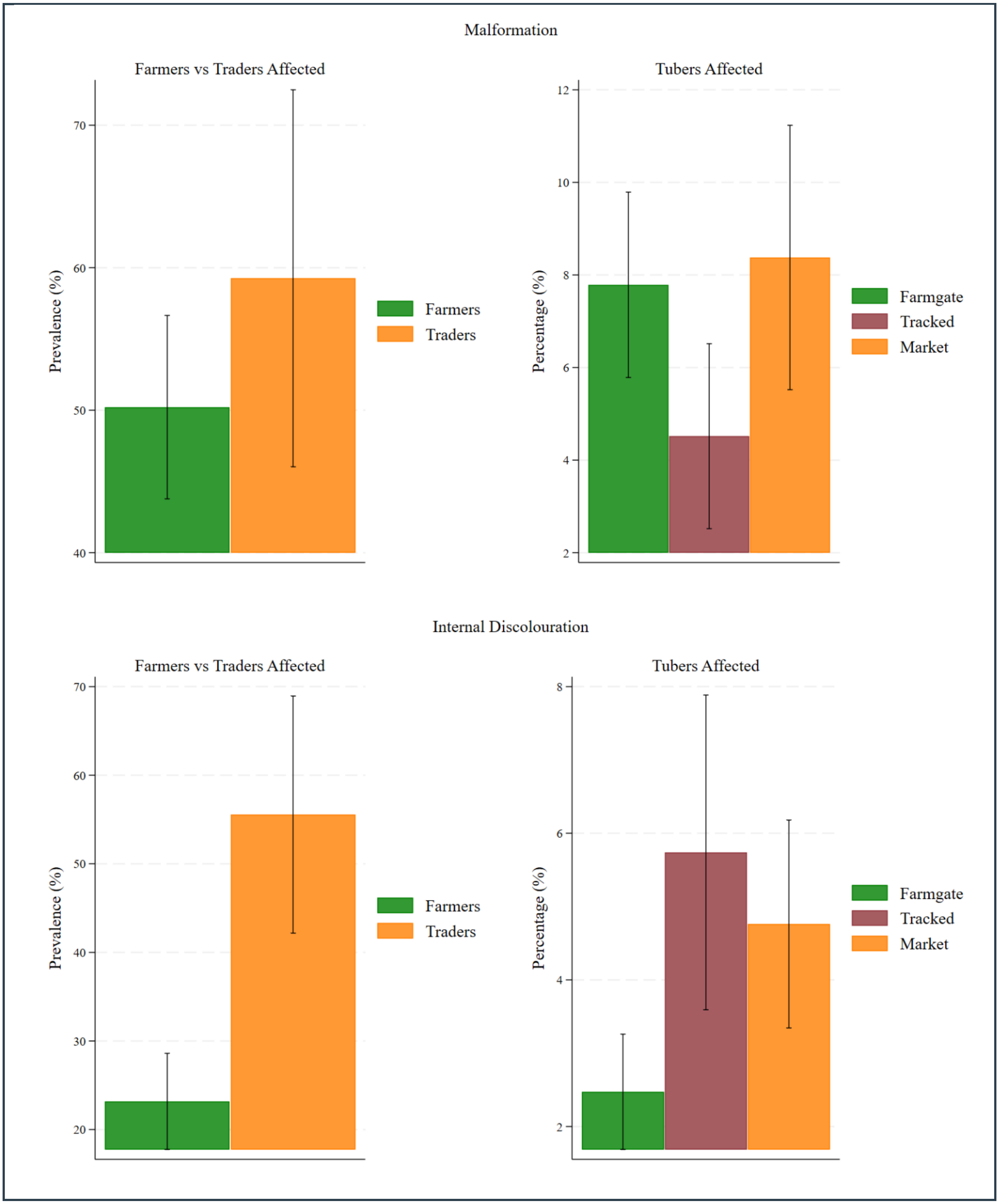
Pest Damage (Internal)
Farmers vs Traders Affected
Prevalence (%)
60
50
40
30
Farmers
Traders
Tubers Affected
Percentage (%)
6
5
4
3
2
Farmgate
Tracked
Market
Pest Damage (External)
Farmers vs Traders Affected
Prevalence (%)
80
75
70
65
60
55
Farmers
Traders
Tubers Affected
Percentage (%)
12
10
8
6
4
Farmgate
Tracked
Market


Bruising
Farmers vs Traders Affected
Prevalence (%)
100
80
60
40
20
Farmers
Traders
Tubers Affected
Percentage (%)
25
20
15
10
Farmgate
Tracked
Market
Cuts
Farmers vs Traders Affected
Prevalence (%)
100
90
80
70
Farmers
Traders
Tubers Affected
Percentage (%)
25
20
15
10
Farmgate
Tracked
Market

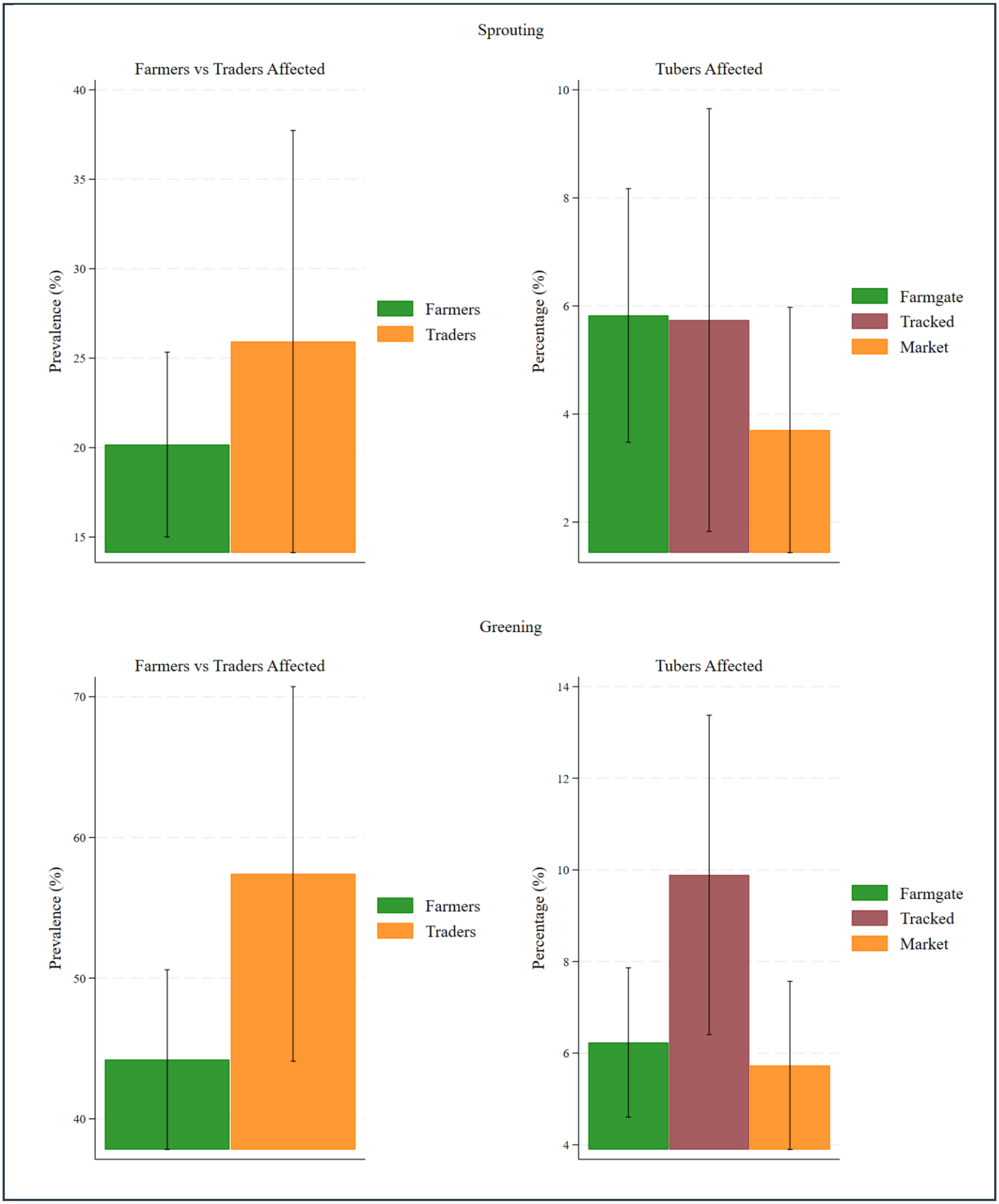

Feathering/Skinning
Farmers vs Traders Affected
Prevalence (%)
100
80
60
40
Farmers
Traders
Tubers Affected
Percentage (%)
60
50
40
30
20
10
Farmgate
Tracked
Market
Internal Physical Damage
Farmers vs Traders Affected
Prevalence (%)
80
70
60
50
40
Farmers
Traders
Tubers Affected
Percentage (%)
15
10
5
Farmgate
Tracked
Market

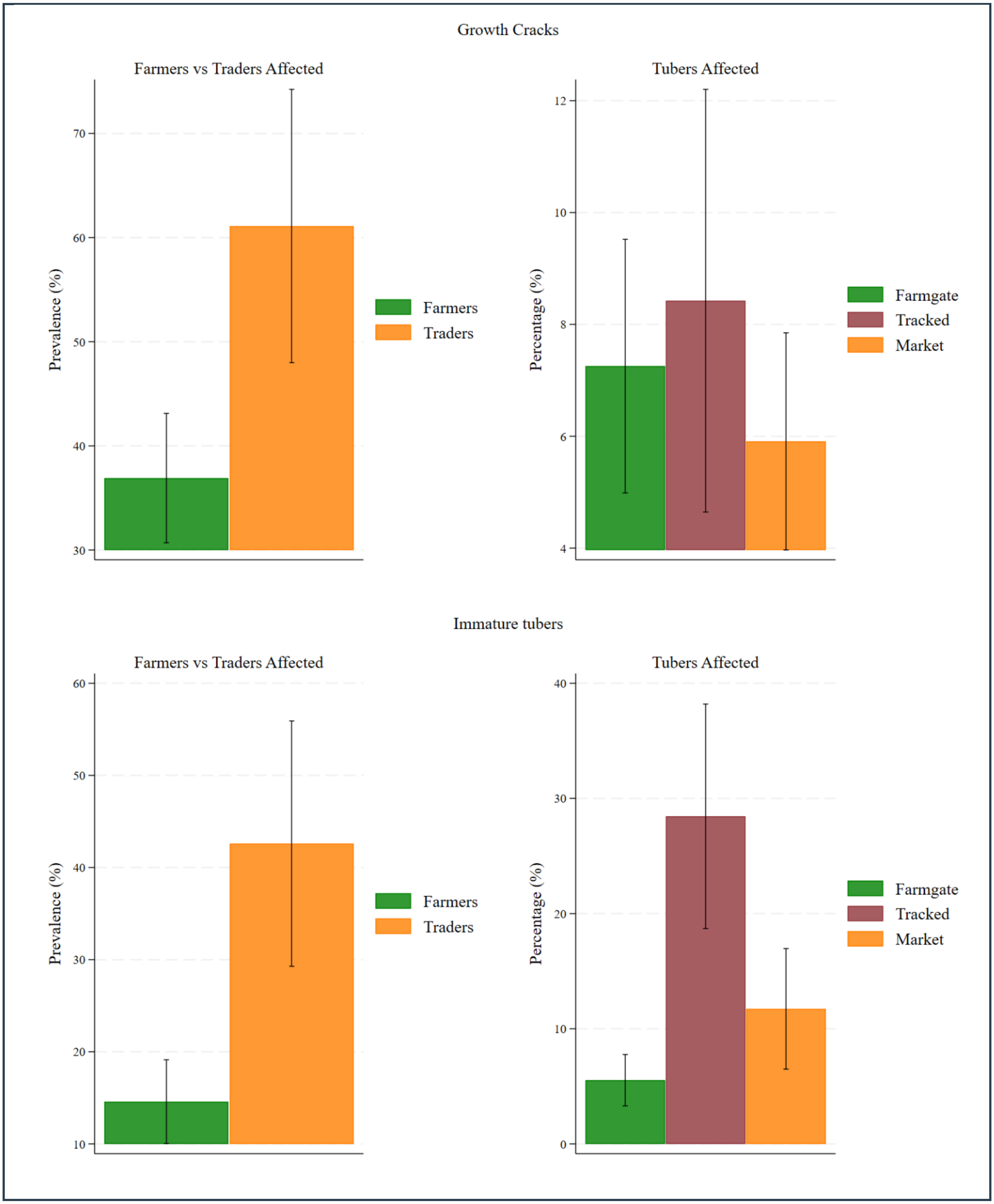


Blackheart
Farmers vs Traders Affected
Prevalence (%)
0
2
4
6
8
Farmers
Traders
Tubers Affected
Percentage (%)
0
.5
1
Farmgate
Tracked
Market
Hollow Heart
Farmers vs Traders Affected
Prevalence (%)
5
10
15
20
25
Farmers
Traders
Tubers Affected
Percentage (%)
0
2
4
6
8
10
Farmgate
Tracked
Market



Malformation
Farmers vs Traders Affected
Prevalence (%)
70
60
50
40
Farmers
Traders
Tubers Affected
Percentage (%)
12
10
8
6
4
2
Farmgate
Tracked
Market
Internal Discolouration
Farmers vs Traders Affected
Prevalence (%)
70
60
50
40
30
20
Farmers
Traders
Tubers Affected
Percentage (%)
8
6
4
2
Farmgate
Tracked
Market


Sprouting
Farmers vs Traders Affected
Prevalence (%)
40
35
30
25
20
15
Farmers
Traders
Tubers Affected
Percentage (%)
10
8
6
4
2
Farmgate
Tracked
Market
Greening
Farmers vs Traders Affected
Prevalence (%)
70
60
50
40
Farmers
Traders
Tubers Affected
Percentage (%)
14
12
10
8
6
4
Farmgate
Tracked
Market



Growth Cracks
Farmers vs Traders Affected
Prevalence (%)
70
60
50
40
30
Farmers
Traders
Tubers Affected
Percentage (%)
12
10
8
6
4
Farmgate
Tracked
Market
Immature tubers
Farmers vs Traders Affected
Prevalence (%)
60
50
40
30
20
10
Farmers
Traders
Tubers Affected
Percentage (%)
40
30
20
10
0
Farmgate
Tracked
Market

This publication has been prepared in the context of the Strengthening Food Systems to Promote Increased Value Chain Employment Opportunities for Youth partnership with the Mastercard Foundation. It is a five-year initiative running between 2022 and 2027 to gain insight into the latest trends and challenges in agrifood systems, and how addressing market inclusion and post-harvest losses can enable dignified and fulfilling livelihoods for young women and men. The publication has also been funded by the CGIAR Research Initiative on Digital Innovation (now transitioned to the CGIAR Accelerator on Digital Transformation) and CGIAR Research Initiative on Nature-Positive Solutions (now part of the CGIAR Science Program on Multifunctional Landscapes), which receive support through the CGIAR Trust Fund The views expressed do not necessarily represent those of the Foundation, its staff, or its Board of Directors. This publication has not been independently peer reviewed. Any opinions expressed here belong to the author(s) and are not necessarily representative of or endorsed by IFPRI or the CGIAR.

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