Tomato Post-harvest Losses as Influenced by Improper Handling Facilities in Morogoro, Tanzania

Mwankemwa, L.S.*, V.C. Silayo, E.L. Lazaro and G.C. Mrema

Department of Food Science and Agro-processing, School of Engineering Sciences and Technology, Sokoine University of Agriculture, P.O. Box 3003, Morogoro, Tanzania

*Corresponding author e-mail: *mwankemwal@gmail.com;* Tel: +255714296966

Abstract

The losses on perishables have been a challenge for so long in developing countries, the current status is critical and its control for small-scale farmers and retailers has not been adequately addressed. The aim of this study was to generate information on tomato handling practices and losses for small-scale farmers and retailers in six selected areas in Morogoro region, Tanzania. A need assessment survey was conducted to help gather information on tomato postharvest handling and practices for the purpose of preparing possible mitigation actions. Sixty respondents with at least 3 years of farming or retailing tomatoes were purposively selected through the help of the extension officer and market leaders to represent part of the tomatoes' handling chain. The SPSS version 16 statistics software was used for data analysis using descriptive statistics. The findings obtained showed that farmers were not using any storage facilities for tomatoes while retailers used inferior handling facilities and some did not use any storage facilities ultimately losing most of their tomatoes. This study found that tomato post-harvest losses (PHLs) were 29.7% at the farmers' level and 18.4% at the small-scale retailers' level during handling and marketing. Besides 60-80% of the farmers and 30-80% of retailers were unaware of the existence of Evaporative cooling structures (ECSs) to avert tomato PHLs. However, 60-80% of all respondents indicated the desire to have ECSs used to improve their tomato business. This prompted the need to have ECSs introduced in order to extend the shelf life of tomatoes while maintaining their quality and hence reducing PHLs.

Keywords: Tomato, Storage, Farmers, Retailers, tomato varieties, Shelf life

Introduction

Tomato (*Lycopersicon esculentum* mill.) is one of the most important widely cultivated and consumed horticultural crops globally. The nutritional and economic importance of this crop has led to its extensive production (Ochida *et al.,* 2019). In most of the areas where it is being cultivated and consumed, tomatoes constitute a very essential part of the people's diet (Arah *et al.,* 2015A). The World Processing Tomato Council (WPTC) reported that global production of tomatoes for the year 2020 was estimated at 39.2 million metric tonnes, with China as the largest producer, estimated to produce about 5.6 million metric tonnes, equivalent to 14.3% (Incrocci *et al.,* 2020) while Africa contributes 11.8% (4.6 million metric tonnes). Within the African continent, tomato is one of the most widely grown vegetables due to its versatility, with production cutting across from smallholder to commercial farming communities (Dube *et al.,* 2020). In Tanzania, the annual total tomato production is estimated at 463,964.74 metric tonnes (FAO, 2022; World Data Atlas, 2021). Tomatoes are grown in many areas within Tanzania, with significant production by smallholder farmers (Mutayoba and Nguruko, 2018; Kapeleka *et al.,* 2020).

In the tomato value chain, postharvest losses constitute a major problem in most of developing countries, but scientific researchers have mainly focused on the production part (Duarte Sierra *et al.,* 2020; Cattaneo *et al.,* 2021). It is also reported that less than 5% of resource allocation in agricultural research in developing countries is on postharvest while more than 95% of resource allocation is on production (Arah *et al.,* 2016). Tomato post-harvest losses

are estimated at 40 to 50% annually between the harvesting and consumption stages of the distribution chain and mostly occur during storage (Kasso and Bekele, 2018). Tomato postharvest losses are mainly caused by many factors including the inherently high moisture content that limit shelf life of about 48 hours under intense ambient tropical conditions (Arah, *et al.,* 2016), hot environmental conditions, and poor post-harvest practices including storage. Other factors include limited knowledge on how to avoid PHL, weak infrastructure, weak institutional support, and limited resources, to afford cost-effective cooling and storage systems (Mahajan *et al.,* 2017; Kasso and Bekele, 2018). The losses accrued are both qualitative and quantitative, which result in poor realization of profit by both farmers and traders (Arah *et al.,* 2015B). The losses can be interpreted as a loss of inputs, energy spent by farmers, soil nutrients, and other resources by stakeholders including farmers and traders.

Currently, the tomato losses status in Morogoro is not documented and its chain control for small scale farmers and retailers has not been adequately addressed. The overall aim of this study was to assess the existing tomato post-harvest handling facilities including storage structures and awareness on PHLs in Mlali ward and retailers within Morogoro Municipality in Morogoro region, Tanzania. Information from this study will be useful for introducing mitigation measures for post-harvest losses, including the design of suitable tomato storage structures and formulation of policies and strategies for the reduction of post-harvest losses.

Material and Methods

Study Area

The study was conducted in Morogoro Municipality located on the foot slopes of the Uluguru Mountains (6°49'15.67" South in latitude and 37°39'40.39" East in longitude with an elevation of around 500 m above mean sea level) in the eastern part of Tanzania and in Mlali ward in Mvomero district in Morogoro region (6°58'0" South in latitude and 37°32'59" East in longitude). Based on the last national census (NBS, 2022), Morogoro Municipality and Mlali ward (Fig. 1) had a population of over 440,000 people and 28, 218 people, respectively. This population constituted important stakeholders of tomato farming and tomato trade. The survey work on retailers was done in three markets (Manzese, Mawenzi, and Nanenane) in Morogoro Municipality and three villages in Mlali ward (Mlali, Mkuyuni, and Kipera) in Mvomero district, which represent part of the tomato handling chain.

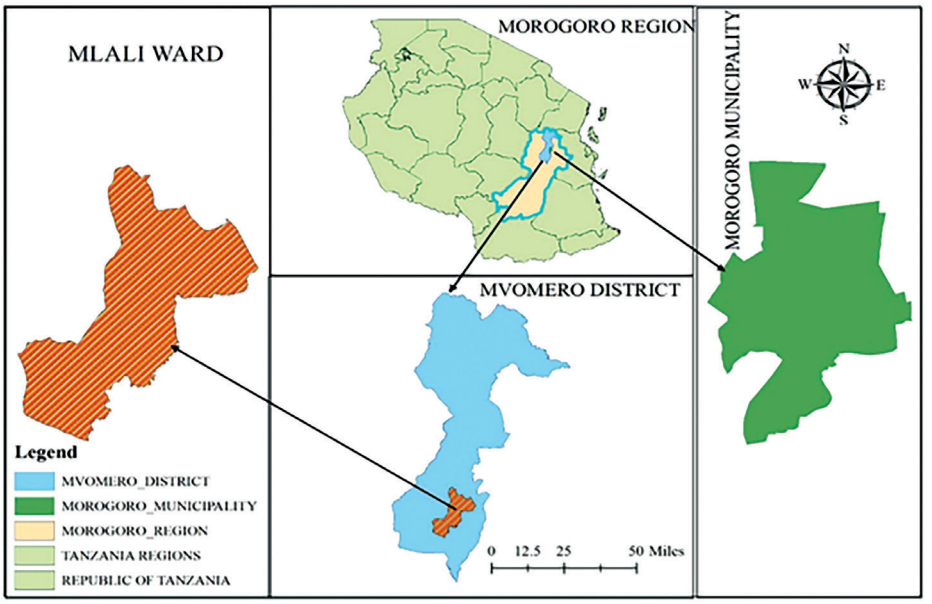

Figure 1: Map of Tanzania showing the study site

Methodology

A purposive sampling technique was used to select the respondents based on knowledge of the population, its elements and the nature of the research aims (Sullo *et al.,* 2020). The other criterion was an experience of at least 3 years of farming or retailing tomatoes. This method was selected because the selected farmers and retailers shared similar characteristics in terms of tomato farming and trading. The postharvest handling related inquiries were prepared, pre-tested with sample respondents, rechecked for appropriateness for clear understanding and responding, and administered. A total of 60 respondents were selected through the help of the ward Agricultural Extension Officer. From the selected respondents, 10 respondents represent one cluster study location (Mlali, Kipera, and Mkuyuni villages; Manzese, Mawenzi, and Nane nane markets).

Data Collection

Data was collected from farmers and retailers through administering a structured questionnaire, which comprised open and close-ended questions; focus group discussion was also carried out in each study location to validate the data. The information collected included the varieties grown in Mlali Ward, current postharvest handling practices, and the associated losses in Mlali Ward and Morogoro municipality. Also the information on awareness of ECSs technology was gathered.

Data Analysis

The collected data was coded and subjected to Statistical Package for Social Sciences (SPSS) version 16 using descriptive analysis. These included means, frequency, and percentages.

Results and Discussion

Description of the tomato varieties grown in Mlali Ward

The tomato varieties grown in Mlali ward and the proportion of farmers involved in their production in the respective villages are presented (Fig. 2). The small scale farmers in all three villages in Mlali ward have shown an overall preference for Asila F1 and Imara F1 varieties. This was attributed to the ability of these varieties to resist diseases, large fruit size, high yields, long shelf life, attractive appearance, and toughness of the fruit mesocarp.

These findings are in line with the findings of Panth *et al.,* (2020) who stated that variety in crop production determines the produce quantity, quality, marketability as well as the ability to tolerate the climate, environmental hazards, and diseases. The findings from the current study are also supported by the results of the study conducted by Palilo, (2019) who reported that Asila F1 and Imara F1 were disease resistant varieties to tomato bacterial wilt and recommended to farmers in the Morogoro region. However, there were no explanations provided with regard to the cultivation of other tomato varieties though at a relatively small scale except T0 135 grown by 20% of farmers only in Kipera village.

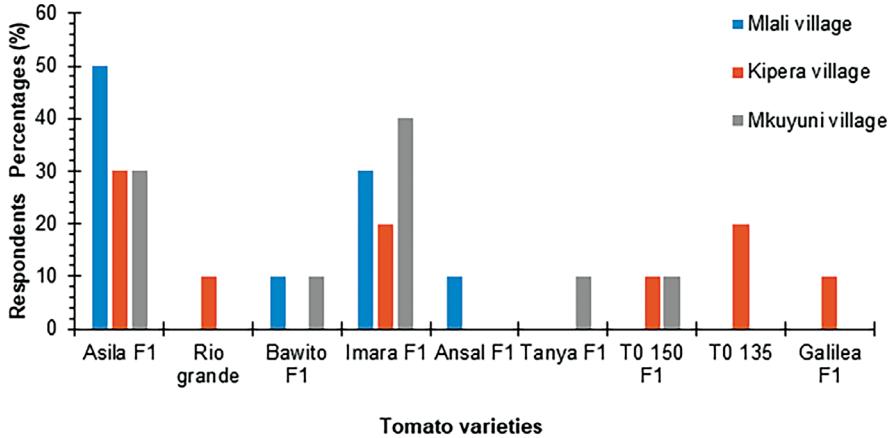

Figure 2: Tomato varieties grown by small scale farmers in Mlali ward

Postharvest handling techniques in the study areas

Results on tomato postharvest handling techniques in Mlali ward (Table 1) have shown that bamboo baskets, wooden crates, plastic crates, plastic buckets and cardboard boxes to be used in handling and transportation of tomato. Majority of the farmers (40-60%) were using bamboo baskets to pack their produce for transportation. This was followed by the use of wooden crates (20–30%), which is increasingly becoming popular. The use of bamboo baskets was due to local availability of fabrication materials and low cost. Bamboo baskets were also used to handle tomato by the majority of traders (40-50%) as they buy loads distributed to them by other traders in these baskets. Of late, 20% of farmers in Mlali and Mkuyuni villages have used plastic crates (Table 1).

Table 1: Current postharvest handling facilities of tomatoes in the study areas

Location	Bamboo basket	Cardboard boxes	Wooden crates	Plastic crates	Plastic Bucket	Open tables	Stalls	Total
Kipera	60	10	20	-	10	-	-	100
Mlali	40	10	30	20	-	-	-	100
Mkuyuni	30	-	50	20	-	-	-	100
Manzese	40	10	-	-	10	10	30	100
Nane nane	40	-	10	-	10	20	20	100
Mawenzi	50	-	-	-	-	20	30	100

Plastic crates, apart from their high initial cost, their use is promising as they can be reused several times compared to other packaging means which are used only once unless they are reworked for suitability of use (Lo-Iacono-Ferreira *et al.,* 2021). Plastic buckets were seldom used except in the Municipal trade centres where use of tables (10-20%) and display in stalls (20-30%) were also practiced. Display in open tables is disadvantageous due to inability to control the environment as well as the fluctuation of weather that may seriously affect the produce respiration rate (Tschirley *et al.,* 2019). Use of full or partially ventilated stalls may give fair results although the challenge of temperature instability may persist on produce quality that may amplify quantitative losses. Use of wooden crates, plastic buckets and cardboard boxes have also been reported to increase perishability rate of tomatoes due to accumulation of field heat and spread of diseases, compression of the produce due to their own weight, and high chances of mechanical damage including bruises (Nkolisa *et al.,* 2017).

Postharvest tomato losses in the study areas

Postharvest losses experienced by small scale tomato farmers and retailers in the different study locations are presented in Figure 3. During handling and marketing of tomatoes, losses by volume of 18.7%, 21.3% and 15.4% approximately were reported at Manzese, Mawenzi, and Nane nane retail markets, respectively. Furthermore, at the small scale farmers' level tomato losses during harvesting and handling were approximately 32.4, 31.0 and 25.3% in Mlali, Kipera and Mkuyuni villages, respectively (Fig 3). It can be hypothesized that most of the tomato losses experienced in the study areas as presented in Figures 3 and 4 were due to the reasons explained in post-harvest handling techniques shown in Table 1 above. Most of these PHLswere influenced by many factors including high ambient temperatures, lack of air circulation, nature of storage, attack by microorganisms, poor transportation means, improper harvesting and handling methods, and pests (including insects) as shown in Table 2. The results from this study are also supported by the study conducted by Nowicki *et al.,* (2012).

The observed on-farm PHLs are in line with the findings in the studies by Lal Basediya *et al.,* (2013) and Kasso and Bekele, (2018) who reported tomato losses experienced by smallholder farmers to be 20 to 35%. Nevertheless, these losses are less than 67%

Table 2: Cross tabulation – highlighted response on causes of postharvest losses in study areas

Losses causes	Kipera village	Mlali village	Mkuyuni village	Manzese market	Nane nane	Mawenzi market	Total reaction
Transportation means and handling methods	1	2	2	2	3	2	12
Nature of storage and lack of ventilation	-	-	-	2	1	1	4
Over ripening and moisture loss	1	2	2	-	1	-	6
Hot weather and Marketing	1	1	1	-	-	1	4
Over ripening, Microorganisms, insects and pests	4	3	4	2	1	2	16
Harvesting method and lack of air circulation		1	1	1		-	3
Hot weather over ripening	3	1		3	4	4	15
Total respondents per area	10	10	10	10	10	10	60

at the farmers' level reported by Nkolisa *et al.* (2017). The estimated PHLs from the current study concur with the findings reported in the study by McKenzie *et al.,* (2017) on tomato losses in developing countries estimated at around 50%. The estimated tomato losses at the retailers' level are in line with results in the study conducted by Kitinoja *et al.,* (2018) who reported PHLs of tomatoes at the retailers' level to be in the range of 15 to 20%, which in most cases might be attributed to high ambient temperature. Hetta and Kamuzora, (1999) reported the highest recorded temperature in Morogoro ranges between 37.2 to 33°C around the month of January, which was close to the time when this study data was collected.

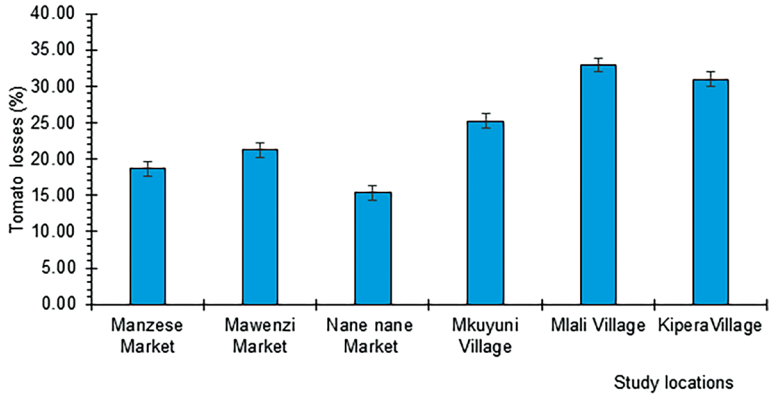

Figure 3: Average percentage PHLs on tomatoes experienced by different villages and markets in Morogoro

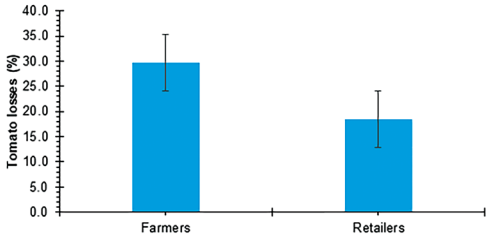

Figure 4: Average percentage PHLs on tomatoes experienced by farmers and retailers in Morogoro

Therefore, the findings from the current study highlight the importance of the development and use of improved postharvest handling facilities to reduce PHLs of the produce and increase their shelf life.

Experienced monetary losses on tomatoes in the study areas

Monetary losses experienced due to PHLs and seasonal selling prices in the study locations are presented (Figs. 5&6). The study findings demonstrated the dry season experienced lower monetary losses compared to the rainy season due to the difference in tomato production and selling prices. At the farmers levels the losses averaged in the range of USD 452-790 during the dry season and USD 1349-1790 per household during the rainy season in all the three villages (Fig. 5). The same trend was shown at the retail level where losses ranged between USD 6 and USD 37 during the dry season and between USD 8 and USD 52 in the rainy season in all the Morogoro municipal markets per retailer (Figure 6). These losses are of greatest concern to retailers and farmers involved in tomato handling as transaction between retailers and farmers or middlemen is a business in expectation of financial returns afterwards (Lenné and Ward, (2010). Bisbis *et al.,* (2018), reported that during dry seasons temperatures are high while there are numerous favorable tomato production conditions including less pests and diseases which contribute to excess production of tomato fruits. Similarly, higher production in dry seasons, improper handling skills, poor knowledge and low awareness on proper storage facilities lead to major produce and monetary losses (Wunderlich and Martinez, 2018).

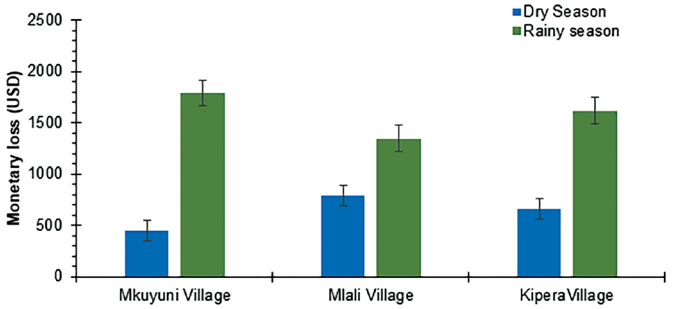

Figure 5: Monetary losses experienced by small scale farmer of tomato at Mlali ward
(United States Dollar (USD) equals to 2,307.00 Tanzanian Shilling: 7 Oct, 2021 11:56 UTC)

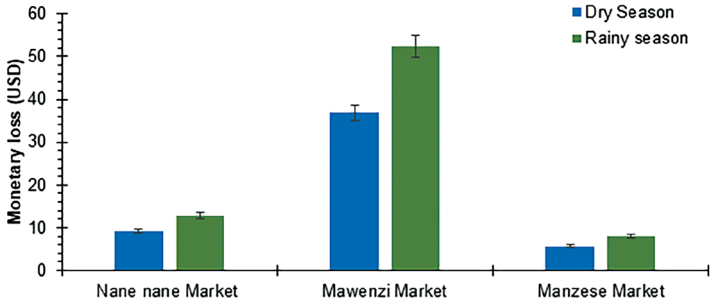

Figure 6: Monetary losses experienced by retailers of tomato in Morogoro Municipality Markets
(United States Dollar (USD) equals to 2,307.00 Tanzanian Shilling: 7 Oct, 2021 11:56 UTC)

Awareness on evaporative cooling systems and testing

Awareness by the small-scale tomato farmers and retailers on ECSs and the interest of using them are presented (Fig. 7). Lack of awareness about ECSs was reported by 70%, 80% and 60% by small scale tomato farmers at Mlali, Kipera, and Mkuyuni villages, respectively. The findings are similar to those by Ndukwu and Manuwa, (2014) which reported that most of the inhabitants in rural areas have never seen or used any evaporative cooling structure (ECSs) in their life time. Lack of awareness on ECSc was reported by 80% of retailers in each of the Mawenzi and Manzese markets and 30% at Nanenane market. However, 70% of tomato retailers at Nane nane market were aware of ECSs as most of them had seen them at exhibition grounds but have never used or tested them. Majority of the respondents were interested in testing the ECSs technology as indicated in Figure 8. Eighty percent (80%) of tomato retailers at Manzese market and 70% at Nanenane market were interested. With regard to farmers 70%, 60%, and 70% in Mkuyuni, Mlali and Kipera villages respectively were interested. This implies that the respondents were interested in technological intervention which would help them save their tomatoes during postharvest storage and marketing.

The Improved Wind Operated Passive Evaporative Cooler (IWOPEC) structure as a new technology in the study locations has raised awareness to most farmers and retailers (Fig. 7). This indicates that the respondents would wish to adopt an intervention, which would help them save their tomatoes during the postharvest phase (Fig. 8). Adoption of ECSs would help tomato

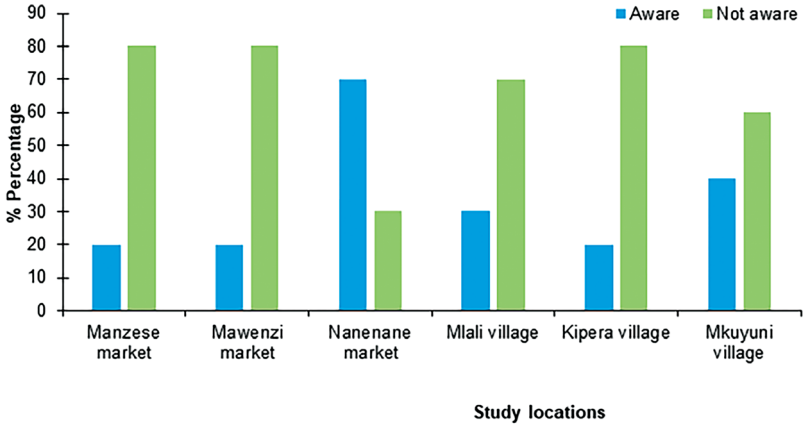

Figure 7: Awareness of tomato farmers and retailers on existence of evaporative cooling structures (ECSs) in Morogoro

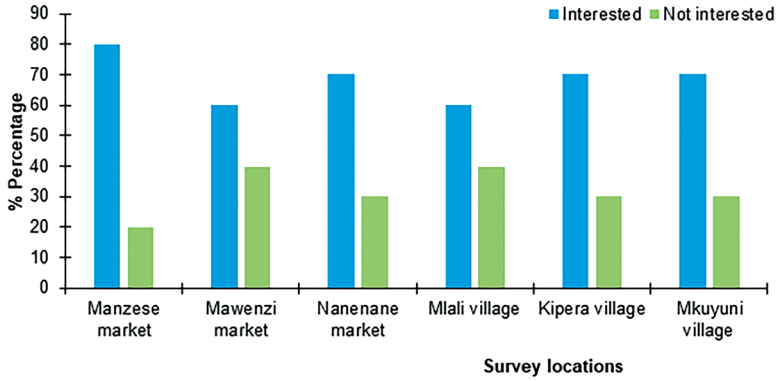

Figure 8: Respondent's interest in using ECSs technology

handlers reduce postharvest losses, since it has the ability to reduce ambient temperatures and increase relative humidity, it can be made using readily available local materials, needs less manpower and is easy to maintain (Nkolisa *et al.,* 2017).

Conclusion

The common tomato varieties grown in Mlali ward and the factors contributing to high post-harvest losses of fresh tomatoes were revealed. The common tomato varieties grown in Mlali ward are Asila F1 and Imara F1. Tomato farmers and retailers are challenged by the large amount of tomatoes lost due to improper postharvest handling methods used by the chain actors including farmers and retailers themselves. Rainy season farming experiences more PHLs compared with dry season farming. Inappropriate storage facilities to store tomatoes after harvest was one of the major value chain challenges faced by farmers and retailers that prompted a need for proper means of storage to be introduced in order to increase tomatoes' shelf life and reduce losses. Most of the tomato retailers and farmers were not aware of evaporative cooling systems that could help them maintain produce shelf life. About 70% of the farmers and retailers were interested in being in possession of the ECSs structure which would be very useful to them and would help reduce tomato postharvest losses. More studies are required to up-scale the ECSs for adoption at Municipal markets and recommendations to stakeholders including policymakers.

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