International Journal of Applied Review
www.multiappliedjournal.com
E-ISSN:3107-8443
Received: 21-10-2025, Accepted: 20-11-2025, Published: 05-12-2025
Volume 1, Issue 2, 2025, Page No. 13-16

Post-harvest technologies and their impact on rural economy and employment generation

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Abstract
Post-harvest technologies play a crucial role in strengthening the rural economy by minimizing food losses, enhancing product quality, and generating employment across agricultural value chains. In many developing countries, particularly in rural regions, a significant portion of agricultural produce is lost due to inadequate storage, inefficient handling, and lack of preservation infrastructure. Post-harvest technologies—encompassing cleaning, grading, drying, storage, packaging, transportation, and processing—provide practical and sustainable solutions to these challenges. The adoption of improved technologies such as solar dryers, cold storage units, vacuum packaging, modified atmosphere systems, and small-scale food processing equipment has significantly increased the shelf life and market value of perishable commodities like fruits, vegetables, milk, and grains. This technological advancement not only ensures food availability and nutritional security but also enhances the income of farmers and rural entrepreneurs by enabling value addition at the community level. From an economic perspective, the deployment of post-harvest technologies stimulates rural entrepreneurship, promotes the establishment of micro and small food enterprises, and reduces dependence on middlemen. The transformation of raw agricultural produce into value-added products—such as fruit juices, pickles, dehydrated vegetables, or flour-based snacks—creates diverse income opportunities and expands rural markets. Moreover, post-harvest processing units encourage women's participation in the workforce, as they often operate small-scale enterprises or cooperatives focusing on traditional and locally processed foods. These activities foster gender-inclusive economic growth and enhance household income stability. The introduction of low-cost, locally adaptable technologies has made it feasible for smallholders and self-help groups to engage in post-harvest operations without large capital investment, thus democratizing access to food processing opportunities. Employment generation through post-harvest technologies is multidimensional. It extends beyond the farm to include technicians, machinery operators, packagers, transporters, and marketers within rural communities. Each stage of the post-harvest chain requires human input, creating seasonal and permanent employment. Additionally, training and capacity-building initiatives in food safety, hygiene, and quality management empower rural youth with technical skills that align with modern agri-food industries. The integration of information and communication technology (ICT) tools, such as mobile-based supply chain management and e-commerce platforms, further strengthens linkages between producers and consumers, ensuring fair prices and reducing wastage. Environmentally, these technologies contribute to sustainable rural development by promoting efficient resource utilization and reducing carbon emissions associated with spoilage and waste. They also encourage the use of renewable energy sources, such as solar-powered drying or cold storage systems, aligning rural economic growth with sustainability goals. Government initiatives, public–private partnerships, and policy frameworks supporting rural food processing clusters and agri-innovation hubs have further amplified the role of post-harvest technologies in rural transformation.

Keywords: Post-harvest technology, rural economy, value addition, food processing, employment generation, sustainability, entrepreneurship

Introduction

Agriculture forms the backbone of rural livelihoods in most developing economies, employing nearly 60–70% of the rural population either directly or indirectly. Despite substantial production gains in recent decades, post-harvest losses continue to undermine agricultural productivity, profitability, and food security. According to the Food and Agriculture Organization (FAO), an estimated 30–40% of food produced globally is lost or wasted due to poor post-harvest management and lack of infrastructure. In India alone, annual post-harvest losses of fruits and vegetables are estimated to exceed ₹92,000 crore (FAO, 2020) [5].

Post-harvest technologies (PHTs) encompass the methods, tools, and systems used to handle, preserve, and process agricultural produce after harvest (Mayanja & Oluk, 2023) [15]. These technologies address critical issues such as perishability, microbial spoilage, and market inefficiencies (Haji *et al*., 2020) [7]. By ensuring quality maintenance and extending shelf life, PHTs transform agricultural activities into value-added processes that stimulate rural income and employment generation (Yogita *et al*., 2024) [32]. Furthermore, they support national objectives of food security, sustainable agriculture, and inclusive economic growth.

Concept and Scope of Post-Harvest Technologies

Post-harvest technology involves the application of scientific and engineering methods to preserve the quality, safety, and value of agricultural commodities after harvest until they reach consumers (Kumar & Kalita, 2017) [13, 14]. It focuses on minimizing losses, maintaining nutritional quality, and enhancing marketability (FAO, 2020) [5]. The major operations include cleaning and grading to remove impurities and classify produce by quality, drying and

dehydration to reduce moisture and prevent spoilage, storage in ambient or controlled environments to extend shelf life, and packaging using improved or biodegradable materials to maintain freshness (ICAR-CIPHET, 2021) [8]. Efficient transportation and distribution systems, such as refrigerated logistics, help retain product quality during transit (Singh & Pandey, 2020) [29]. Furthermore, processing and value addition—such as making pickles, jams, flours, or juices—transform raw produce into higher-value goods (MoFPI, 2021) [17]. Collectively, these technologies not only reduce post-harvest losses but also enhance product value, promote rural entrepreneurship, and generate employment across the agricultural value chain (World Bank, 2022) [31].

Impact on Reduction of Post-Harvest Losses

One of the most direct benefits of post-harvest technologies (PHTs) is the reduction of post-harvest losses. Losses occur at various stages—harvesting, handling, storage, transportation, and marketing. Technologies such as improved packaging materials, hermetic storage bags, and temperature-controlled logistics have proven effective in mitigating these losses (Kumar & Kalita, 2017) [13, 14]. For example, the introduction of low-cost solar dryers in rural India has reduced post-harvest fruit and vegetable losses by nearly 30%, enabling farmers to store and market produce during off-seasons when prices are higher (Mujumdar, 2020) [19]. Similarly, cold storage facilities have revolutionized the dairy and horticulture sectors by ensuring year-round supply and maintaining product quality (Affognon *et al*., 2015; Singh *et al*., 2022) [1, 27, 28].

Value Addition and Rural Entrepreneurship

Post-harvest technologies enable value addition, transforming raw produce into higher-value products that generate more income and employment. This process includes drying, milling, juicing, fermenting, and packaging (Kumar *et al*., 2021) [12]. For instance, tomato processing into sauces, mango into pulp, or milk into cheese and yogurt significantly increases market value (FAO, 2019) [6]. Rural entrepreneurs, self-help groups (SHGs), and cooperatives increasingly engage in such value addition using small-scale machinery and locally available resources (Singh & Pandey, 2020) [29]. The establishment of mini food parks and rural processing units—supported by government initiatives like the Pradhan Mantri Kisan Sampada Yojana (PMKSY)—has further strengthened local entrepreneurship ecosystems (Ministry of Food Processing Industries (MoFPI, 2023) [18]. Women-led SHGs play a pivotal role in such enterprises. Studies have shown that 30–40% of rural food-processing ventures in India are operated by women, contributing to both empowerment and economic resilience.

Employment Generation through Post-Harvest Operations

Post-harvest technologies create employment both directly and indirectly across the agri-food value chain (FAO, 2019) [6]. Direct employment arises in processing units, packaging houses, and storage facilities, while indirect employment includes machinery maintenance, logistics, retailing, and marketing (Kumar *et al*., 2020).

The development of small-scale agro-processing enterprises and rural food industries further enhances livelihood opportunities, particularly for women and youth, thereby contributing to inclusive rural economic growth (Singh & Devi, 2021) [26].

The stages of employment generation include

- **Primary Level:** Sorting, grading, cleaning, and handling operations at the farm level.
- **Secondary Level:** Processing, drying, packaging, and labelling in food units.
- **Tertiary Level:** Marketing, transportation, ICT-enabled trading, and export operations.

Moreover, PHT-based industries provide both seasonal employment (during harvesting or processing seasons) and permanent jobs (in maintenance, management, and retail). The multiplier effect of these operations is significant, as income from processing and marketing activities circulates within rural economies, supporting local development.

Role of ICT and Digital Technologies

The integration of Information and Communication Technologies (ICT) has transformed post-harvest management (Meera, Jhamtani, & Rao, 2018) [16]. Mobile-based applications for supply chain tracking, digital weighing, and e-commerce platforms such as eNAM and KisanMandi connect farmers directly to buyers, reducing intermediaries (Reddy & Ankaiah, 2020) [23]. ICT-driven cold chain management ensures optimal temperature and humidity throughout transportation, minimizing spoilage (Chaudhary & Bhatnagar, 2019) [4]. Digital literacy programs and rural innovation hubs further train youth in operating such technologies, aligning them with the demands of the modern agri-food industry (Singh & Sharma, 2021) [26].

Environmental and Sustainability Implications

Post-harvest technologies play a vital role in promoting environmental sustainability by reducing food waste, which in turn lowers methane emissions from decomposing organic matter and mitigates climate change (Kumar & Kalita, 2017) [13, 14]. The adoption of renewable energy systems, such as solar-powered dryers and cold storage units, helps minimize dependence on non-renewable energy sources, reducing the carbon footprint of rural industries (Rao *et al*., 2020) [22]. Additionally, the use of biodegradable and eco-friendly packaging materials contributes to waste reduction and environmental protection (Bhat *et al*., 2021) [3]. These technologies also emphasize efficient utilization of water and energy resources in processing operations, ensuring sustainable production practices (Sharma & Singh, 2018) [24]. Overall, the integration of such eco-conscious interventions aligns with the United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), and SDG 12 (Responsible Consumption and Production), thereby fostering a greener and more resilient rural economy (United Nations, 2015) [30].

Table 1: Post-Harvest Technologies and Their Impact on Rural Economy & Employment Generation

Post-harvest technology	Short description	Impact on rural economy (income/markets/food security)	Employment generation (types of jobs created)	Key sources
Cold storage / refrigerated storage (cold rooms, refrigerated trucks, coolbot cold-rooms)	Temperature-controlled storage for perishables (fruits, vegetables, dairy, fish) to slow spoilage and extend sale window.	Reduces seasonal glut losses, enables access to distant/higher-value markets, improves farmer price realization and reduces waste. Improves year-round supply and local value chain activity.	Jobs: cold-store operators, transport drivers with refrigerated vehicles, technicians (maintenance/repair), packers, seasonal workers for handling. Enables small processing businesses.	Amadu *et al*., 2024 [2]
Hermetic storage & metal silos (grain bags, PICS bags, sealed metal silos)	Airtight storage solutions that protect dry grains from pests and moisture without chemicals.	Dramatically lowers post-harvest losses for cereals/legumes, improving shelf life and farmer incomes; strengthens food security and ability to time sales for better prices.	Jobs: local manufacturers/retailers of bags/silos, extension/installation technicians, warehouse labor, transport & aggregation roles.	Jarman *et al*., 2023 [9]
Improved drying technologies (solar dryers, mechanical dryers)	Technologies to reduce moisture in produce (grains, fruits, herbs) faster and more hygienically than open-sun drying.	Lowers mould/aflatoxin risk and quality losses; enables production of dried value-added products (powders, dried fruit) that fetch higher prices.	Jobs: dryer manufacturers/assemblers, operators, small-scale processors (drying, packaging), quality control/testers, traders.	Kirui *et al*., 2025 [10]
Small-scale processing & value addition (juicing, pulping, drying, pickling, milling)	Village or micro enterprises that convert raw produce into higher-value products (pulp, oils, pickles, powders).	Creates local value chains, increases farmer share of final price, enables product diversification and new markets (local retail, institutional buyers, exports). Strengthens rural MSMEs and FPOs/FPCs.	Jobs: small food processors, women-led microenterprises, packagers, quality testers, marketing & sales, logistics. Often generates many part-time and permanent roles.	Kitinoja *et al*., 2023 [11]
Mechanical shellers / threshers & sorting/grading machines	Machinery that speeds removal of husk/shells, and automated sorting & grading for quality.	Improves product quality and uniformity, reduces drudgery, raises throughput and farm gate value; enables sellers to meet buyer specs and access markets.	Jobs: machine operators, maintenance/repair technicians, local fabricators/assemblers, calibration/quality staff. Can reduce some manual labor but creates higher-skill maintenance roles.	Sigar, 2021 [25]
Improved packaging (modified atmosphere packaging, improved barrier films, biodegradable options)	Packaging that extends shelf life and preserves quality during transport and storage.	Enables longer transport distances and reduces spoilage; supports branding and higher prices; can		Noukpozounkou *et al*., 2025 [21]

Conclusion

Post-harvest technologies have emerged as a cornerstone of rural economic transformation by minimizing food losses, improving quality, and creating employment opportunities across agricultural value chains. The integration of innovative, affordable, and sustainable technologies ensures not only food and nutritional security but also income diversification for rural households. By empowering smallholders, youth, and women through entrepreneurship and skill development, these technologies catalyze inclusive growth. Effective policy support, investment in rural infrastructure, and technology transfer mechanisms will further strengthen the role of post-harvest technologies in achieving sustainable rural development and national food security.

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