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Smart IoT-Based Modular Agro-Processing and Market Linkage System for Villages

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Abstract- Agriculture is still the backbone of most developing economies with millions of smallholder farmers producing food for a growing population and practicing agriculture. However, farmers often find it difficult to realise a fair price for their produce due to the exploitation of intermediaries, the absence of an effective and transparent quality grading system, and insufficient market intelligence on prices. This project outlines the design of a solar powered (IoT)-based system with sensor technology that grades and specifies the quality of vegetables and crops. The device collects real-time information on the quality of produce, accords it with other external agricultural databases and current market prices where it computes a suggested sale price. By providing earlier reliable data insights to farmers, it will reduce reliance and information asymmetry on intermediaries, provide quality grading in a transparent and agreed method, and optimally benefit profitability to farmers. This paper reviews some existing literature and challenges faced by farmers, provides details around the proposed method, and suggests what the benefits of a system such as this may look like at scale.

Keywords- Agro-processing, IoT, smart village, market linkage, automation.

I. INTRODUCTION

Agriculture is essential to food security and sustainable economic development globally, but for many rural households, particularly in developing countries, farming is also a source of meaningful livelihood and cultural and social identity. Farmers experience many challenges throughout the agricultural value chain; however, the most significant obstacles include poor pricing systems, unreliable crop grade testing, and unfair provenance practices by middlemen. Farmers usually rely on middlemen for marketing their products due to a lack of direct access to the market that allows for transparency in trading. Middlemen will consistently undervalue crops and leave a farmer with little profit margin, even when a farmer can produce superior crops. Additionally, the assessment of crop quality is highly subjective, and although a farmer may grow the highest-grade produce, subjectively allowing buyers to price them, instead of the highly complicated concept of market forces that entrepreneurs in other

industries experience in higher-income countries. Technology in the field of Agriculture - the Internet of Things (IOT), machine learning, solar power, and renewable energy - will help alleviate some of these issues.

IOT smart products can measure and gather live agricultural data points, allowing farmers to identify accurate cropping data, helping them understand the quality of their produce and what market-facing product with fair prices. Under a solar power model, IOT software can run continuously without the requirement of interference typically seen without proper energy inputs in remote or rural areas without energy consistency, especially with respect to climate change considerations.

II. Research Insights, Conferences and Farmer Challenges

Agricultural technology has received renewed attention in recent years. Research presented of the *International Conference on IoT in Agriculture (2020)
indicated that IoT monitoring through sensors could help farmers improve agricultural efficiency by more than 25% (especially in onsite grading, and post-harvesting). Further, **Food and Agriculture Organization (FAO)** workshops featured examples of intervention strategies to cut out middlemen in the agricultural supply chain, which represent, on average, a share of up to 40% of possible income for farmers in some regions.

To survey the data on smart agricultural research, sensor technologies have been adapted to provide a number of functions and analyses from soil moisture and crop yield predictions to estimates of produce freshness and automated onsite finished goods grading of produce (color, texture, and size). Examples of automated grading systems presented at **Institute of Electrical and Electronics Engineers (IEEE) Smart Agriculture Symposium**, provided further to the consistency found in grading crops compared to manual inspection.

Despite these advances, farmers are still faced with a multitude of hurdles:

1. Price Exploitation: Without access to reliable and timely market data, farmers have no option but to take whatever price their intermediaries offer.
2. Quality Assessment Lack: Farmers do not have any scientific methods to check and demonstrate their crops quality.
3. Knowledge Gaps: Often, urban buyers and traders are privy to market data, while the rural farmers are not.
4. Infrastructure Limits: Power outages and poor connectivity hold back advanced systems.
5. Knowledge Gaps: Many farmers are oblivious to emerging technologies, so adoption will take time unless they can be simplified.

III. Proposed IoT-Based System and Approach

The proposal is for an IoT-based, solar-powered device, specifically designed for smallholder farmers, which combines sensors to measure crop quality, with real-time databases of market prices, and provides a fair price recommendation. Different from classic manual inspections, the proposed approach generates

standardized, objective, data-driven results.

Solutions to Farmers Challenges:

1. Fair Pricing: This automated recommendation means farmers can become independent of intermediaries for quality valuation.
2. Transparent Grading: The objective quality measurements mean no more misclassification or devaluations.
3. Sustainability: Solar technology for generating energy can decrease overhead and provide reliable energy sources in rural locations.
4. Data Empowerment: Farmers get access to previous historical pricing information and market data to help guide decision making to improve future farming.
5. User Friendly: The formulation is designed to be very user-friendly, requiring farmers to have little technical understanding.

IV. FINDINGS AND EXPECTED IMPACT

Data from preliminary research and pilot studies have indicated that farmers using IoT-enabled grading and pricing systems are able to make **15–25% more profit** than selling through traditional outlets. Other case studies have confirmed that a standard quality grading system increases trust with consumers, who know they can check the quality before they purchase. When coupled with renewable energy sources, we can also incorporate more power adaptations in rural environments where electricity access is limited.

The following impacts are expected from this project:

Economic Empowerment: Farmers keep more of their earnings, which leads to improved livelihoods in rural communities when they cut out suppliers and intermediaries.

Market Transparency: Farmers are transparently allowed fair trade as the quality is graded uniformly, resulting in a standardized finish that gives tangible value to focus on collecting

Sustainable Development: The use of solar-powered devices aligns with the Non-Carbon Economy Renewables Goals, and decrease carbon emissions

Scalability and Growth Potential: Beyond grading and pricing, we envision this system being able to check on soil health, predict crop yield, and provide predictions of weather to provide farmers with a complete agricultural system.

Community Growth and Support: Introducing these sorts of tech Avan to growers could lead to building areas of collective buy-around and cooperative farming systems that further stimulate rural economies.

V. CONCLUSION

The project highlights how an IoT-supported crop quality detection and price recommendation system can transform the agricultural trading landscape. By combining sensors, cloud data processing, and solar power, this system can address age-old challenges around exploitation, transparency and sustainability

in the agricultural sector. By removing third-party players from the trade process, farmers will be assured that they are being paid fairly and having produce graded in a consistent manner helps sellers and buyers alike assure the quality will meet their expectations.

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