



Emerging Trends and Challenges in the Commercialization of Agricultural Technologies: An Extension Perspective

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Agriculture has been perceived as a harsh reality where elbow grease takes the place of modern technologies. Modern technologies are used with the aim of improving yield, efficiency, and profitability. Agricultural Technology can be defined as products, services or applications derived from agriculture which is useful to enhance different input and output processes developed in agriculture. Technology has been a major driver of both the agricultural productivity increases of the past century and the financial success of many farm and agribusiness firms. Generally, farmers are perceived to be rapid adopters of new technology, and those agribusiness firms that have been innovative and creative in their R&D activities have been rewarded with strong market positions and financial success. But the challenges of bringing new technology to market in the agricultural industry are changing – it is no longer adequate to conceive a new invention and convince farmers with a strong marketing campaign that they should adopt the technology that results from this invention. The business challenges in the commercialization of agricultural technology are both more complex and broader with respect to those who will be impacted by that technology.

Agricultural Technologies mean changes in farming efficiency, productivity, and sustainability which includes increase in cropping intensity/optimization of land use, enhanced farming and modernized agri-engineering incorporating: more effective tractors, increased access to tractor harvester combined units proportional to area under commercialization on a country's export competitive base, better HGPS (High-Precision Global Positioning System) and drone.

Commercialization of Agricultural Technologies

Commercialization of agricultural production is an endogenous process that goes along with economic growth, urbanization and withdrawal of labor from the agricultural sector. This is the process of bringing agricultural technologies and innovations to the market while combining it with existing technologies for sustainability.

Commercialization of technologies involves:

- Developing and processing technologies for practical use.
- Ensuring technologies are accessible and affordable for farmers and agribusinesses.
- Creating supportive infrastructure and market linkages.
- Providing financing options to facilitate adoption.

It aims to convert innovative solutions into widely used practices that enhance agricultural productivity, sustainability, and economic viability.

Emerging trends of agricultural technology commercialization

1. **Rise of Precision Agriculture:** The concepts of precision agriculture are a new addition to the Israel landscape in the form of an agricultural approach which integrates data in order to foster suitable practices for agricultural productivity and preservation. Such an approach employs the soil, climate or other aspects of data science and directs it into the effective use of agricultural resources. The increasing adoption of drones or sensors and satellite images into agriculture has made it possible to visualize and assess land, soils and crops, sparing farmers from a lot of guess work, but rather making sound decisions. The number of startups and established firms offering precision agriculture continues to grow steadily.
2. **Biotechnology Innovation:** Biotechnological advancement is the greatest impact of the above on through the work of GMOs and genomic editing through CRISPR technology. Such tool kits bring a lot of benefits to the table including improving the types, pest resistance and improving the level of nutrient and content. There is some stiff regulatory challenge causing turbulence; however, marketing of biotech products is slowly taking wings, particularly in advanced economies leading to better market coverage and acceptance.
3. **Digital Farming Solution:** Farmers' access to information and resources such as supervisory agencies, financial institutions, and other necessary inputs have changed completely as a result of the presence of digital platforms and applications. There are various ways to enhance a farm's market efficiency and access; among them are farm management software and e-commerce platforms that allow farming products to be sold online. The uptake of these technologies is being made easy with the increased number of smartphones penetrating rural areas which is also hastening commercialization processes.
4. **Climate Smart Agriculture:** Climate-Smart Agriculture (CSA) is an incorporated approach which aims to manage livelihoods, food systems, and other resources in a long lasting development way while adapting to climate change. Specifically, it aims to improve agricultural production and productivity, build resilience and mitigate GHG emissions. The CSA and agricultural extension education are closely related in all aspects of its implementation and even adaptation in the farm sector for instance an education plus strategy. Climate-Smart Agriculture adapts to climate-smart agricultural practices that are climate-resilient. Examples of these practices are growing crop varieties that are drought resistant, managing water effectively, agroforestry, and practicing fertile and well-compacted soils.

Challenges in Commercialization

Commercializing agricultural innovations and services through agricultural extension education faces several challenges. Here is a deeper look into each issue:

Adoption Barriers

- Farmers cannot be eager to use new technologies and practices due to traditional beliefs or fear of risk.
- Many farmers especially small holder farmers, don't know about new innovations or understand their benefits.
- Some of the solutions to be embraced may be too complex for farmers, who might find it difficult to integrate them into their existing practices.

Limited Access to Finance

- There are times when the farmers are unable to get repayable credit, insurance, and other financial instruments that will help them invest in modern technologies.

- The agriculture industry is characterized with a high level of risk in regard to further climatic changes and price fluctuations, which makes financial institutions reluctant to extend loans to smallholder farmers.
- Unfamiliarity with many financial products and services among farmers that may also restrict their ability to secure funding.

Market Access & Infrastructure Constraints

- Low quality roads, absence of cold chains, and inefficient storage space may also limit the scope of market access for agricultural products.
- Farmers have no access to timely as well as accurate information touching on market prices, preferences, and even the demand for particular products.
- Ineffective value chains that are marked with several layers of middlemen may compromise the profitability of agricultural products on farmers.

Regulatory and Policy Issues

- Bureaucratic practices such as wide registration processes for new agricultural products or certifications may inhibit commercialization.
- Price control measures or subsidies provided for traditional crops may discourage farmers from employing new cropping methods which may be more profitable.
- Decidedly, low levels of investment on agricultural structural, researching and extension services are hardly supportive in fostering commercialization.

Knowledge and Skills Gap

- Sometimes, the number of the qualified extension agents do not fulfill the requirements of a large rural population. Available extension agents are fewer than expected in most cases.
- There are extension outreach programs that are outdated or ineffective which reduces their impact when they are utilized.
- It is critical to ensure that farmers or intended beneficiaries comprehend how to use sophisticated farming practices and technologies effectively.

Way forward

The role of extension is to bridge the gap between modern, data-driven agricultural technologies and farmers' needs. There is dire need to update knowledge of farmers on precision farming adoption by assisting them in decision-making to tailor the knowledge to site-specific conditions or real situations encountered by farmers, and in providing information on new or recently modified techniques, practices, and services.

Extension service provider need to organize programmes that educate farmer to understand the benefit of GM crops, their proper use and safety measures. Extension agent also provide training on the benefits of diseases resistant crops and how to manage pest and diseases outbreak using biotechnology solutions. The farmers need to sensitize and aware about the availability of biofortified crops and their health benefits including their establishment into diets and how they fit into the farmers' agricultural routines.

Extension educators and Digital Farming are closely linked, both pursue the common goal of enhancing agriculture and agricultural output. Digital farming uses technology such as smartphones, sensors, satellite data and other digital tools to optimize farming processes, while extension educator focuses on training farmers and disseminate relevant information. It also plays a crucial role in educating farmers about these digital tools and technologies. They have been able to bridge this knowledge gap by availing training on the application of these tools and technologies in ordinary farming routines. Agricultural extension programs provide capacity-building opportunities through workshops, field demonstrations, and digital literacy training. It provides services that teach farmers how to interpret data provided by digital tools, such as weather forecasts, soil health reports, or crop yield predictions. It also helps

farmers to make data-driven decisions that improve productivity and sustainability. Extension agents can also inform farmers on how to utilize their digital devices to comprehend information related to the performance and outcome of their farms.

Extension service provider play a instrumental role in enlightening farmers on the concepts of CSA. Extension officers or trainers raise awareness of climate risks, provide information about nobel climate-smart agricural practices, and motivate locals to practices CSA methods on their farm. Extension educators help farmers to learn some of these practices, teaching them through field school or workshops, as well as during on-site trainings. This helps the farmers to cope up with climate shocks such as floods and drought, and even extreme weather events. Extension services can also lobby for policies and subsidy frameworks that are supportive for the adoption of practices such as climate smart agricultural practices.