**Innovation Capability of Agro Startups: from Digitalization to Sustainability**

**Author 1.** Ms. Vrinda Tikkha

Research Scholar & Guest Faculty

Email: vrindatikkha1502097@dei.ac.in

**Author 2.** Ms. Prachi Agarwal

Research Scholar

Email: prachiagarwal180981@dei.ac.in

**Author 3.** Dr. Rohit Rajwanshi

Assistant Professor

Email: rohit0108@dei.ac.in

Department Of Management

Faculty of Social Sciences

Dayalbagh Educational Institute (Deemed to be University)

Dayalbagh, Agra, 282005

**Abstract**

This chapter offers a comprehensive exploration (endogenous and exogenous) of the innovation capability of agro-based startups leading to digital transformation and subsequently to overall sustainable performance. It provides an in-depth analysis of the global landscape of agro startups, with a particular emphasis on the vibrant ecosystem in India, while illuminating the transformative potential of digital technologies in reshaping traditional agricultural practices. The study encompasses both endogenous and exogenous factors, which are meticulously examined, offering nuanced insights into their interplay within the startup environment. Furthermore, the chapter categorizes sustainability performance indicators across social, economic, and environmental dimensions, emphasizing the necessity for startups to prioritize comprehensive sustainability measures. By integrating discussions on digital transformation, the chapter underscores the intertwined progress achieved by agro startups, catalyzing advancements across societal, economic, and environmental fronts, thus paving the way for a more resilient and sustainable future.

**Key Terms:** Agro-based Startups, Innovation Capability, Digital Transformation, Sustainable Performance

**Introduction**

Agriculture is an integral part of the Indian economy. Agriculture and its related sectors are the main source of livelihood for most of the Indian population. Around 70% of rural households rely on agriculture for survival, while a significant 82% of farmers fall under the category of small and marginal landholders. (Press Information Bureau, 2022). The digitalization of Indian agriculture can be backdated to June 2000 when ITC launched its e-Choupal initiatives to help the rural society. It was an online platform that directly connected farmers to the internet, enabling them to purchase agricultural and many more products available for the farmers. (ITC).   
In 2023, rural areas in India accounted for over 442 million internet users, surpassing half of the nation's total of 820 million active users. The year also saw an 8% increase in internet penetration in rural regions. Notably, rural India boasted a higher number of internet users compared to urban areas, with 425 million users in rural settings as opposed to 295 million in urban locales. (Indian Express, 2024). This signifies a significant shift towards digital transformation in agriculture, as the widespread use of the internet has expanded access to agricultural knowledge and the availability of agri-tech solutions. These solutions encompass various aspects, including finance, insurance, technological advancements, forecasting, supply chain management, and the buying and selling of produce. (Economic Times, 2024).   
Farm management has emerged as a key focus of digital innovation in agriculture. Through the use of mobile applications and software platforms, farmers now have access to real-time information on crucial factors such as weather forecasts, market prices, and pest outbreaks. (Paraforos, D. S.,et.al, 2016). An example of this is the Government of India's mKisan portal, which offers personalized advisories tailored to farmers' specific locations and crops, empowering the farmers and all other associated people to make informed decisions.  
  
Digital transformation has spurred innovation in startups across various sectors, including agritech. According to recent data, the number of startups leveraging digital technologies for transformation has been on the rise. For instance, in India, there are over 1,500 agritech startups, with more than 250 of them receiving funding. This indicates a growing interest and investment in digital solutions within the startup ecosystem. (Economic Times, 2023). Moreover, the impact of digital innovation is evident in the success of these startups. Many have reported significant growth and scalability attributed to their adoption of digital technologies. (Kraus, S., et.al,2021) For example, agritech startups utilizing mobile applications and software platforms. Furthermore, the digital transformation of startups has not only improved operational efficiency but has also enhanced their competitiveness in the market. Deloitte's research indicates that digitally mature organizations, including startups, are 2.5 times more likely to be top performers in terms of revenue growth and profitability. Startups leveraging digital tools can reach a wider audience, access valuable data insights, and innovate faster than traditional businesses. (McKinsey & Co).

The digital and innovation culture in India is on the rise and with that is the rise of startups as registered under the Startup India initiative is more than 1 lakh. (Startup.gov). According to research by IBM Institute for Business Value and Oxford Economics, 90% of Indian startups fail within the first five years. So it becomes important to understand the different variables that play a role in the innovation journey of a startup.

**Background**

**Agro-Based Startups in India & Global Scenario**

* **Agro-based Startups in India**

India relies heavily on its agricultural sector, which engages 118.7 million farmers, constituting over half of the country's population. Despite the limited incorporation of technology, the agricultural sector makes a modest contribution of 16-17% to the nation's GDP. However, there is a notable rise in the number of agritech startups in India, aiming to improve technology accessibility and uplift the living standards and quality of life for farmers (IBEF India, 2023).

The rise of India's digital ecosystem, driven by the expanding digital content economy and the increased accessibility and affordability of high-speed internet, presents a significant opportunity for stakeholders in the agricultural sector to challenge the existing norms by leveraging advanced technologies. These technologies include data analytics, data platforms, digitalization of data, AI, ML, IoT, and software as a service (SaaS). While recent government initiatives such as the liberalization of APMC markets are expected to benefit the agricultural sector, the full potential of India's agriculture will only be realized through widespread adoption of technology (EY India, 2020).

In December 2017, the Indian Ministry of Agriculture, in collaboration with Start-up India, initiated the Agriculture Grand Challenge (AGC) to address 12 predefined issues through innovative solutions from companies nationwide. The competition garnered 1,066 entries, and following five mentorship workshops involving over 400 agritech businesses, 20 promising ideas were selected for further development. These startups focus on diverse aspects of the food processing and related ecosystem, including product innovation, packaging enhancement, supply chain optimization, technology advancement, storage and transportation improvement, food safety assurance, and e-commerce and retail models. Forecasts suggest that the Indian agritech sector could potentially attract more than $10 billion in investment over the next decade (FICCI-PwC, 2021).

Agrotech startups are fundamentally transforming conventional agricultural practices throughout the entire value chain. The burgeoning digital content economy, combined with the widespread availability and affordability of high-speed internet, is propelling India's digital ecosystem. This convergence presents a significant opportunity for stakeholders in the agricultural sector to reshape traditional norms by leveraging cutting-edge technologies, encompassing data analytics, digital platforms, AI, ML, IoT, and Software as a Service (SaaS). While recent governmental initiatives, such as the liberalization of APMC markets, are expected to bring benefits to the agricultural sector, the complete realization of India's agricultural potential hinges on the widespread adoption of technology. This notion is substantiated by examples such as:

**Market Connections**: Providers of farm inputs are seamlessly integrating physical infrastructure and technology to provide inputs with improved cost stability.

* **Farm Management and Precision Agriculture**: Entities in this domain are aiding farmers in achieving significant yield increases, up to 30%.
* **Quality Management and Traceability**: Farmers have the opportunity to enhance their income by rewarding high-quality produce, facilitated by the interventions of quality management and traceability players.
* **Supply Chain Technology and Output Market Linkages**: Participants in this sector are effectively minimizing inefficiencies, such as excessive waste of farm products, benefiting both farmers and consumers. (Tikkha, V., 2023)

Furthermore, financial service providers may extend loans to 30% of farmer families, and crop insurance may be availed by 65% of farmer households. (startupindia.gov.in)

Given their expansive scale, resilient repeat ordering patterns, and significant profits, startups in the agro-based sector emerge as an attractive option. Following the aftermath of the COVID-19 pandemic, the industry must reassess its strategies beyond those employed in 2019 to ensure competitiveness and sustainability. Taking into account various pivotal growth factors, there is a pressing need to prioritize the implementation of solutions associated with strategies aimed at enhancing the performance of startups on food tech platforms. (McKinsey & Company, 2022).

In the Indian context, agricultural startups are actively tackling challenges faced by farmers by blending innovative ideas with technological solutions. On a global scale, countries like the United States, China, and the United Kingdom are leveraging technology to instigate a transformative revolution in agriculture, effectively bridging the gap between the final agricultural product and end users. Agricultural startups contribute solutions across the entire agricultural value chain, offering diverse products, applications, and services. The Indian startup ecosystem, particularly in agriculture, is a subject of international discourse. A notable trend is the increasing preference of many talented young individuals for entrepreneurship over conventional paths such as multinational corporations and government sectors. These startups are actively addressing widespread problems, marking a significant shift in the landscape (Anand & Raj, 2019).

**Figure 1: Percentage Share of Different Agriculture Sector in Agro-Based Startups**

**Source:** Startupindia.gov.in

Figure 1 suggests that among the agro-based startups, 55% are with agri-tech startups which include precision farming, weather forecasting, irrigation systems, crop prediction and many more. The second alternative for the existing entrepreneurs is food processing startups which are gaining attention as the needs and requirements of the people in food are changing rapidly. According to investindia.gov.in, the Indian food processing market is expected to grow to $535 billion by 2025-26, with a compound annual growth rate (CAGR) of 15.2% which is an emerging opportunity.

In 2017, India experienced a decline, witnessing the addition of only 1,000 new technology-based businesses. However, there was a resurgence in 2018, with the incorporation of 1,200 new tech ventures. By 2023, the number of start-ups in India exceeded 99,000. The integration of modern technology in business-to-business (B2B) firms and the continuous improvement of support systems are driving the Indian tech start-up ecosystem towards significant progress. (livmint,2023).

* **Agro-based startups' global scenario**

The global agriculture market witnessed an increase from $12,245.63 billion in 2022 to $13,398.79 billion in 2023, demonstrating a Compound Annual Growth Rate (CAGR) of 9.4% (EY, 2023). However, the global economic recovery from the COVID-19 pandemic has been hindered by the Russia-Ukraine war, resulting in economic sanctions, a notable rise in commodity prices, and disruptions in the supply chain. This has led to inflation affecting various global markets. Despite facing these challenges, there is an expectation that the agriculture market will reach $19,007.8 billion by 2027, sustaining a CAGR of 9.1% (EY, 2023).

The global population is growing and is estimated to reach 10 billion by the year 2050, leading to a heightened demand for food resources. As indicated by the Organization for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization (FAO), there is a projected 13% increase in global cereal production by the year 2027. In response to the needs of this expanding population, an expected upsurge in crop production, farming engagements, and trade volumes is foreseen. To enhance crop production and meet the escalating demand, agribusiness companies are inclined to acquire more arable land and extend their reach and activities (Agriculture Outlook, 2022).

In the dynamic landscape of global agriculture startups, innovation is at the forefront as these startups utilize technology to address diverse challenges in the agricultural sector. As of 2023, numerous startups globally are actively contributing to the transformation of agriculture. Key trends and influential players in this space are characterized by:

1. **Adoption of Advanced Technologies:** Agtech startups are at the forefront of integrating state-of-the-art technologies such as AI, data analytics, and IoT. These advancements aim to enhance efficiency, sustainability, and overall productivity in various aspects of agriculture.
2. **Varied Solutions:** Agriculture startups present a diverse range of solutions, covering precision farming, supply chain optimization, farm management, and sustainable agricultural practices. The array of offerings significantly contributes to the ongoing evolution of global agricultural practices.
3. **Rapid Sector Growth:** The agriculture startup sector is experiencing substantial growth, attracting significant investments. This growth underscores the sector's pivotal role in advancing farming techniques and global food production.

This innovative and dynamic landscape highlights the commitment of agriculture startups worldwide to meet the evolving needs of the industry, emphasizing sustainability and improving overall efficiency in agricultural processes (Forbes, 2021).

**Literature Review**

**What is Innovation?**

Innovation can mean differently for different entities, and under different circumstances, its meaning is subject to change. Simply, it can be stated that “innovation is the management of all the activities involved in the process of idea generation, technology development, manufacturing and marketing of a new (or improved) product or manufacturing process or equipment” (Paul Trott, 2006). One of the more comprehensive definitions is: “Innovation is not a single action but a total process of interrelated sub-processes. It is not just the conception of a new idea, nor the invention of a new device, or the development of a new market. The process is all these things acting in an integrated fashion” (Myers and Marquis, 1969).

Further, innovation can be defined as:

“The term innovation may refer to both radical and incremental changes to products, processes or services. The often unspoken goal of innovation is to solve a problem. Innovation is an important topic in the study of economics, business, technology, sociology, and engineering. Since innovation is also considered a major driver of the economy, the factors that lead to innovation are also considered to be critical to policymakers” (Merriam-Webster Dictionary).

“Innovation is defined as change that creates a new dimension of performance… Innovation is a creation (a new device or process) resulting from study and experimentation; the creation of something in the mind; the act of starting something for the first time; introducing something new” (Drucker, P. F. ,2002)).

* + **Evolution of Innovation**
    - **Early Views on Innovation (19th Century):**

Initially, there was a very limited understanding of how technological progress specifically contributed to economic growth. In the 1930s, Schumpeter emphasized the significance of new products as a catalyst for economic growth. Marx proposed a linkage between innovations and waves of economic growth, suggesting a cyclical nature to the development of economies. Scholars like Schumpeter, Kondratieff, Abernathy, and Utterback further expanded on this. (Trott, P. Trott.,2017)

* + - **Post-World War II Interest in Economic Growth and Innovation (1940-60s):**

Industrial research and development (R&D) gained significance, and studies conducted in the 1950s delved into the internal economic characteristics of the innovation process.

* + - **Contrasting Neo-Classical Economics and Business Management/Strategy – Schumpeterian View of Firms (1960s):**

Neo-classical economics focused on economy-wide performance and ignored differences among firms in the same industry. In contrast, the perspective of business management and strategy research focused on these distinctions and the decisions that led to them, placing a new emphasis on the internal activities of the firm. From the Schumpeterian viewpoint, firms were seen as unique entities whose innovation performance is shaped by how they manage resources over time. This perspective highlights the influence of internal management on the innovation capability of firms

* + - **Two Traditions of Innovation Studies (1970s):**

Two distinct traditions of innovation studies, one in the USA and another in Europe, emerged. The American tradition focused on technological change, while the European tradition, significantly credited to Christopher Freeman, shifted the focus to introduction of change and commercialized invention.

* + - **Recent and Contemporary Studies (20th Century-Present):**

The Schumpeterian and evolutionary theory of dynamic firm capability highlighted the significance of firms' ability to acquire and utilize knowledge for developing new products. Marketing's role in understanding and satisfying customer needs was discussed, with a distinction between disruptive and sustaining innovations. Currently, innovations are frequently linked with groups of people or companies rather than individuals. (Trott, P. Trott., 2017)

* + **Kondratieff Wave:**

Kondratieff and Schumpeter (journey from 1920-2008) have played a crucial role in delineating the stages of innovation development, evident in the five waves or growth cycles. These cycles underscore the spatial dimension of technological advancements and innovations, where leadership in one wave does not necessarily extend to subsequent waves, leading to observable geography change of innovation over time.

During the first wave, the leading positions were taken by Britain, France, and Belgium, followed by the United States and Germany in the second wave. The third wave saw the continued dominance of the United States and Germany, with Japan and Sweden entering the competition in the fourth wave. More recently, in the fifth wave, Taiwan and South Korea have emerged as significant players in the global economy. The Kondratieff waves depict the growth of the capitalist economy based on significant innovations in product, process, and organization, accompanied by corresponding shifts in social perspectives. Each wave concludes due to inherent shortcomings, prompting the succeeding wave to fundamentally restructure and rectify those weaknesses. Each major innovation phase gives rise to a "star" industry or branch that influences the overall organization of the economy. (Tyulin, A. E., et al,2023).

* + **Innovation Capability**

“Innovation capability is the ability of the firm to transform knowledge repeatedly and ideas into new products, processes or systems so as the firm and its stakeholders are benefited to the maximum” (Lawsons & Samson, 2001).

Organizations must enhance their performance through innovation to attain business value and a competitive edge (Damanpour, 1991). The challenge arises from the disparity between an organization's aspirations, actual achievements, and its inherent capability, often resulting in difficulties or failures in sustaining successful innovation projects (Pisano, 2015). The ability to excel in replicating innovation success varies among companies and is termed as innovation capability (Aas, T. H., and K. J. Breunig, 2017).

In the field of resource-based or dynamic capability, the discipline of business administration highlights innovation capability as a fundamental competency for organizations striving for competitive advantages. An organization's innovation capability encompasses the knowledge that positively influences its strategic decisions. This refers to the organization's potential to acquire, absorb, transform, and apply knowledge, reflecting its learning capability—indicative of how well organizational members actively embrace new advancements. Research has identified distinct types of abilities that collectively constitute innovation capability, including entrepreneurial capability, marketing capability, learning capability, networking capability, and resource exploitation capability (Oura et al., 2016). Some of the innovative firms and its explanation for high innovative capability are Apple – “Innovative chief executive”, Google – “scientific freedom for employees”, Samsung- “speed of product development” Proctor & Gamble-“utilization of external sources of technology”, BMW – “design”, Starbucks-in-depth understanding of customers and their cultures” and Totyota-“Close cooperation with suppliers” (Trott, P., 2013)

**Innovation Audit to Assess Innovation Capability**

Firms can conduct an innovation audit to identify strengths and weaknesses in specific areas and devise strategies to enhance overall performance. Following are the factors of a straightforward yet effective audit, using the organizational characteristics as a framework for evaluating the firm's innovation performance capability. This method has proven to be a valuable starting point for senior managers to assess improvement opportunities and allocate resources wisely.

**Table 1: Innovation Audit Factors**

|  |  |
| --- | --- |
| * Growth orientation | * Vigilance |
| * Commitment to technology | * Cross-functional cooperation |
| * Acceptance of risks | * Assemble knowledge |
| * Receptivity | * ‘Slack’ |
| * Adaptability | * Diverse range of skills |

***Source: Innovation Management and New Product Development***

**Understanding Exogenous and Endogenous Variables in Innovation Capability**

Navigating the terrain of innovation capability in agro-based startups requires a holistic perspective that considers the intrinsic qualities of these ventures alongside the external forces that shape their trajectory. Endogenous variables, stemming from within the startups themselves, encapsulate the entrepreneurial spirit, management practices, and the adaptability of the workforce. These internal elements play a pivotal role in fostering innovation, as they determine a startup's ability to ideate, experiment, and implement novel solutions within the agricultural domain. On the other hand, exogenous variables, originating from the external environment, encompass market demands, governmental policies, and global economic trends. The influence of these external factors extends beyond the immediate control of startups, challenging their adaptive capability and influencing the direction of their innovative pursuits. Table 2 shows all the identified variables both exogenous and endogenous. Recognizing the intricate interdependence of these endogenous and exogenous variables is essential for crafting a nuanced understanding of how agro-based startups carve their niche in the ever-evolving landscape of agricultural innovation for the betterment of all stakeholders.

**Table 2: List of Endogenous and Exogenous Variables**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Endogenous Variables** | **S.No** | **Exogenous Variables** |
| **1** | Entrepreneurial Orientation | **1** | Government Policies |
| **2** | Market Orientation | **2** | Barriers to entry |
| **3** | Absorptive Capacity | **3** | Education and skill level |
| **4** | Organisational Structure | **4** | Technological Infrastructure |
| **5** | Learning Capacity | **5** | Demographic trends |
| **6** | Inter-functional Coordination | **6** | Availability of Capital |
| **7** | Employee Engagement | **7** | Trade Policy |

* **Endogenous variables**

Endogenous variables are variables that are determined within a system or model. They are influenced by other variables within the system and are not considered to be independent or exogenous. In the context of economic or econometric models, endogeneity refers to the property of a variable being determined by other variables in the model. It is important to distinguish between exogenous and endogenous variables in decision-making processes, as both types of variables can have significant impacts on the outcomes. In econometric models, the specification of endogeneity and exogeneity is crucial for accurate model estimation and interpretation. (Buscha, F., & Conte, A., 2013), (Torraco, R. J. 2003).

After reading different research like Carla Susana Marques, João Ferreira (2009), Amir Grinstein (2008), Juho-Petteri Huhtala, Antti Sihvonen (2013), Filip De Beule, Annabel Sels (2014), Ajay K. Kohli & Bernard J. Jaworski (1990), John C. Narver & Stanley F. Slater (1990), Minna Saunila (2020), Margarida Vicente and José Luís Abrantes (2014), Naala, M., Nordin, N., & Omar, W. A. B. W. (2017), Cemal Zehir, Esin Can, Tugba Karaboga. (2015) the following conclusion can be derived showing the relationship between these endogenous variables and innovation capability.

Entrepreneurial Orientation (EO) serves as a backbone in determining the innovation trajectory of agro-based startups. EO encapsulates the startup's willingness to take risks, its proactiveness in seeking new opportunities, and its overall commitment to innovation. In the context of agro-entrepreneurship, a high level of EO manifests in a willingness to invest in research and development for novel agricultural techniques, explore alternative farming methods, and experiment with innovative approaches to crop management. This orientation creates an organizational culture that not only tolerates but encourages calculated risk-taking, fostering an environment where employees are motivated to think outside conventional boundaries, thus amplifying the innovation capability of the startup.

Market Orientation (MO) is integral to understanding and responding effectively to the evolving needs and preferences of customers in the agricultural sector. Agro-based startups with a strong MO continually analyze market trends, consumer behavior, and competitive dynamics. By staying attuned to the demands of the market, these startups can identify gaps or unmet needs, laying the foundation for innovation. For instance, a startup with a keen market orientation may identify a growing consumer preference for organic produce and subsequently innovate its cultivation methods to meet this demand, thus showcasing how market awareness directly influences the innovative endeavors of agro-startups.

Absorptive Capacity (AC) is the startup's ability to assimilate and apply external knowledge effectively. In agro-based startups, this translates to the capability to integrate emerging technologies, industry best practices, and the latest scientific advancements into their agricultural processes. High absorptive capacity allows startups to stay at the forefront of innovation by adopting cutting-edge solutions, enhancing their overall capability, and promoting continuous improvement in agricultural practices.

Organizational Structure (OS) plays a pivotal role in determining how efficiently agro-based startups can innovate. A flexible and decentralized structure promotes a culture of creativity and responsiveness. In the agricultural context, this may mean that a startup with a more fluid organizational structure can swiftly adapt to changing weather patterns, market demands, or regulatory shifts, thereby facilitating a faster and more effective response to challenges and opportunities. Conversely, a rigid structure may impede innovation by introducing bureaucratic hurdles and slowing down decision-making processes.

Learning Capacity (LC) is an internal factor influencing the innovative prowess of agro-startups. Startups with a robust learning capacity continuously evolve and improve their practices based on past experiences, whether successes or failures. This adaptive learning process ensures that the organization becomes more adept at handling challenges and capitalizing on opportunities over time, contributing to a cumulative enhancement of their innovation capability.

Inter-functional Coordination (IfC) is vital for agro-based startups, ensuring that different departments collaborate seamlessly to bring innovative ideas to fruition. For example, a startup focusing on developing sustainable farming practices requires effective coordination between the research and development team, marketing, and production departments. Siloed operations can hinder the flow of information critical to the innovation process, emphasizing the importance of breaking down organizational barriers to foster collaboration.

Employee Engagement (EE) emerges as a critical factor in the innovation capability of agro-based startups. Engaged employees are more likely to contribute creative ideas, take initiative, and invest discretionary effort in their work. In the agricultural sector, this could translate to employees suggesting innovative irrigation techniques, proposing environmentally friendly pest control methods, or participating actively in community engagement initiatives. Fostering a culture of employee engagement, therefore, becomes pivotal in creating an environment that nurtures innovation and sustains the startup's competitive edge.

In essence, the intricate interplay of EO*,* MO, AC*,*OS, LC, IfC, EE defines the innovation capability of agro-based startups. By understanding and leveraging these endogenous variables, these startups can navigate the dynamic landscape of agricultural innovation, ensuring not only survival but also thriving in the face of ever-evolving challenges and opportunities.

* + **Exogenous Variable**

Exogenous variables are external factors that are not directly influenced by the company but have a significant impact on its marketing environment. These variables are often related to broader economic, social, technological, and regulatory forces that shape the market in which the company operates. For instance, changes in consumer preferences, shifts in demographic trends, economic fluctuations, technological advancements, and government policies are all examples of exogenous variables that can profoundly affect a company’s marketing efforts. (Sogawa, Y., Shimizu, S., Hyvärinen, A., Washio, T., Shimamura, T., & Imoto, S., 2010).

A thorough literature review done reading the following authors like Alam, S. S., Arumugam, V., Nor, N. G. M., Kaliappan, P., & Fang, L. S. (2013), , Seo, Y., J. Dinwoodie, and D. Kwak. (2014), H. Salavou, G. Baltas and S. Lioukas (2001), Saunila, M. (2016), Liao, S. H., Fei, W. C., & Chen, C. C. (2007), Ramos, P. H. B., & Pedroso, M. C. (2021), Frishammar, J., Kurkkio, M., Abrahamsson, L., & Lichtenthaler, U. (2012), Guan, J., & Ma, N. (2003) these reading states the relationship between innovation capability and the exogenous variables the conclusion to which is provided in the following passage.  
Government Policies wield substantial influence on the innovation capability of agro-based startups, serving as crucial exogenous variables. Policies related to agriculture, environmental regulations, and incentives for research and development can significantly shape the operating landscape for these startups. Favourable policies, such as subsidies for sustainable farming practices or grants for technological adoption, can act as catalysts, fostering an environment conducive to innovation. Conversely, stringent regulations or inconsistent policies may pose challenges, inhibiting the ability of agro-startups to navigate and invest in innovative practices effectively.

Barriers to entry constitute another external factor impacting the innovation landscape for agro-based startups. High barriers, such as substantial capital requirements, complex regulatory compliance, or limited access to distribution channels, can impede the entry of new players into the market. The level of competition within the agro-industry directly affects the pressure for startups to innovate. Low barriers may encourage a surge in startups, intensifying competition and prompting innovative differentiation strategies. Conversely, high barriers can lead to a concentrated market where the few existing startups may have less impetus to innovate.

Education and Skill Level within the workforce represent critical exogenous variables for agro-based startups. A well-educated and skilled workforce is essential for the adoption of advanced agricultural technologies, sustainable practices, and innovation-driven approaches. Educational programs that specifically address the needs of the agro-industry can enhance the pool of talent available to startups, fostering a skilled workforce capable of driving innovation in areas such as precision agriculture, biotechnology, and sustainable farming practices.

Technological Infrastructure is a fundamental external variable influencing the innovation capability. Access to advanced technologies, such as precision agriculture tools, data analytics, and smart farming equipment, can significantly enhance the efficiency and innovation potential of startups. Adequate technological infrastructure enables startups to collect and analyze data, optimize resource use, and implement cutting-edge solutions, thereby contributing to their overall innovative capacity.

Demographic Trends play a pivotal role in shaping the market conditions for agro-startups. Shifts in population size, age distribution, and consumer preferences directly impact the demand for agricultural products and services. Startups attuned to changing demographic trends can align their innovation efforts with emerging market needs, capitalizing on opportunities presented by evolving consumer behaviour.

Availability of Capital is a critical exogenous variable that profoundly affects the based startup’s innovation. Access to funding sources, including venture capital, government grants, and loans, enables startups to invest in research and development, technology adoption, and market expansion. Adequate capital empowers startups to undertake riskier but potentially more innovative projects, contributing to their overall capacity for sustained innovation.

Trade Policy represents an external factor that can shape the competitive landscape for agro-based startups. International trade agreements, tariffs, and import/export regulations influence market dynamics and access to global markets. Favourable trade policies can open up new opportunities for startups to expand their reach and collaborate with international partners, fostering an environment that stimulates cross-border innovation and technology transfer.

**Figure 5: Conceptual Framework**

**Endogenous Variables**

* Entrepreneurial Orientation
* Market Orientation
* Absorptive Capacity
* Organisational Structure
* Learning Capacity
* Inter-functional Coordination
* Employee Engagement

**Sustainable Performance**

* Economic Performance
* Social Performance
* Environmental Performance

**Digital Transformation of Agro Based Startups**

**Innovation Capability of Agro Based Start-Ups**

**Exogenous Variables**

* Government Policies
* Barriers to entry
* Education and skill level
* Technological Infrastructure
* Demographic trends
* Availability of Capital
* Trade Policy

**Authors Construct**

In summary, the innovation capability of the startups are intricately linked to a complex interplay of exogenous variables. Government policies, barriers to entry, education and skill levels, technological infrastructure, demographic trends, availability of capital, and trade policies collectively shape the external environment in which these startups operate. Here the author constructed a framework Figure 5 that shows the flow which eventually shows the relationship among the 4 concepts discussed in the chapter those are endogenous and exogenous variables, innovation capability, digital transformation and sustainable performance. A clear understanding and strategic adaptation to these external factors are essential for agro-based startups to effectively navigate challenges, capitalize on opportunities, and remain at the forefront of innovation in the dynamic agricultural industry. Now further the clear relation between the first two stages of the conceptual framework will be seen with the sustainability performance indicators and digital transformation.**Top of Form**

**Sustainability Performance**

The success of startups doesn’t necessarily be the economic indicators but also social and environmental as well which leads to overall sustainability of the firm. Therefore, the performance indicators of any startup should be threefold (Economic, Social and Environment) what is popularly called as triple bottom line. Sustainability performance in the context of cultivating innovation capability for sustainable development of agro-based start-ups refers to the assessment and evaluation of start-ups' sustainability. Within the realm of agro-based startups, a commitment to sustainability forms the cornerstone, acknowledging the intricate synergy of social, economic, and environmental dimensions. As these startups navigate the terrain of innovation (mainly in agro based startups), a comprehensive examination of their impact unveils a tapestry woven with threads of societal advancement, economic robustness, and ecological stewardship for all the stakeholders. In delving into the societal sphere, the transformative influence of innovation is apparent in initiatives fostering empowerment, enhancing healthcare accessibility, advancing education, and instigating positive lifestyle shifts within the communities they touch. Economically, innovation acts as a catalyst for job creation, the circulation of wealth within local economies, a steady income flow, and the fortified economic foundations of the startups themselves. Simultaneously, agro-based startups showcase a dedication to environmental sustainability, embracing practices that conserve resources, safeguard biodiversity, diminish carbon footprints, and establish eco-friendly operational standards. This holistic exploration illuminates the multi-faceted nature of sustainability within the agro-startup paradigm, where innovation propels these ventures toward a future where economic prosperity intertwines seamlessly with social progress and environmental well-being.

* **Social Performance**

The innovation capability of agro-based startups can have transformative effects on various social aspects, particularly in rural societies. Let's explore the potential impact on women empowerment, healthcare, education, and lifestyle changes:

1. **Women Empowerment:** Agro-based startups, through their innovative approaches, have the potential to significantly contribute to women empowerment in rural areas. By introducing modern agricultural techniques and technologies, these startups can create diverse employment opportunities that go beyond traditional roles. Women may become involved in tasks such as precision farming, agro-processing, and marketing. Moreover, the introduction of more efficient and technology-driven farming practices can help alleviate the physical burden traditionally placed on women in agriculture, providing them with more time for skill development, education, and participation in decision-making processes within the community.
2. **Healthcare Facilities:** The agro-based startups innovation capabilities can indirectly contribute to improvements in healthcare facilities in rural areas. Increased economic opportunities and income generated by innovative agricultural practices can lead to better access to healthcare services. Startups that prioritize employee well-being may also provide healthcare benefits to their workforce, indirectly benefiting the entire community. Additionally, innovations in agro-processing can lead to the production of healthier and more nutritious food products, positively impacting the overall health and well-being of the local population.
3. **Education:** Agro-based startups can play a pivotal role in advancing education in rural areas. Increased economic prosperity resulting from innovative agricultural practices can lead to improved access to education for children. Startups may invest in community development programs, including educational initiatives, scholarships, and vocational training. Furthermore, the introduction of innovative farming techniques often involves the dissemination of knowledge and skills, contributing to a culture of learning and curiosity within the community. This, in turn, can have a positive ripple effect on overall educational attainment and literacy rates.
4. **Lifestyle Changes:** The adoption of innovative practices by agro-based startups can catalyze lifestyle changes in rural societies. Technological advancements may lead to increased mechanization, reducing manual labor and allowing for more leisure time. Improved income levels may contribute to a higher standard of living, enabling communities to access better housing, sanitation, and amenities. Furthermore, the introduction of innovative and sustainable agricultural practices can encourage a shift towards more eco-friendly and health-conscious lifestyles, influencing dietary choices and overall well-being.

In summary, the agro-based startup's innovation capability in rural areas has the potential to bring about holistic improvements in social aspects. By empowering women through diversified employment opportunities, indirectly contributing to enhanced healthcare facilities, promoting education, and catalysing positive lifestyle changes, these startups can become catalysts for comprehensive social development within the communities they serve.

* + **Economic Performance**

The economic impact of agro-based startups' innovation capability extends to rural and urban societies, influencing factors such as employment generation, circulation of money, regular income, and overall economic development. Let's explore these aspects:

1. **Employment Generation:** The agro startups of innovation capability contributes significantly to employment generation. In rural areas, where these startups often have a strong presence, innovative agricultural practices create jobs across various stages of the supply chain, from cultivation to processing and distribution. Women and youth, in particular, may benefit from diversified employment opportunities as startups introduce modern farming techniques and value-added processes. In urban areas, the innovation-driven expansion of agro-based startups may result in job creation in areas such as research and development, marketing, logistics, and technology support.
2. **Circulation of Money:** The economic impact of agro-based startups is not confined to the direct beneficiaries but extends to the entire local economy. Innovations in agriculture can lead to increased productivity and higher yields, boosting the income of farmers and those engaged in the agro-value chain. The increased income, in turn, circulates within the local economy as farmers and workers spend money on goods and services, creating a multiplier effect. In urban areas, where startups may have headquarters or processing facilities, the circulation of money is amplified through salaries, investments, and partnerships, contributing to the broader economic ecosystem.
3. **Generation of Regular Income:** The innovation capability related to startups play a pivotal role in the generation of regular income for individuals engaged in agriculture and related activities. Modern farming techniques, precision agriculture, and value-added processes can lead to more predictable and sustainable income streams. For rural communities, this can translate into reduced income volatility, providing a sense of financial security. Additionally, the incorporation of technology and innovation in agro-processing and distribution enhances efficiency, ensuring a steady flow of income for those involved in these stages of the supply chain.
4. **Economic Factors for Startup Benefits:** Agro-based startups themselves experience economic benefits through their innovation capability. Technological advancements and process innovations can lead to cost efficiencies in production, reducing operational expenses. Improved agricultural practices may result in higher-quality yields, enhancing market competitiveness and profitability. Furthermore, innovations that address environmental sustainability and resource optimization can contribute to long-term economic resilience for startups, ensuring their viability in the face of changing market conditions.

In summary, the economic impact of a startup’s innovation capability is multifaceted. It encompasses not only the direct economic benefits to individuals and communities but also the broader economic ripple effects. The generation of employment, circulation of money within local economies, the regular income of individuals, and the economic advantages realized by the startups themselves collectively contribute to fostering economic growth and sustainability in both rural and urban societies.

* + **Environmental Performance**

The environmental impact of the innovation capabilities is a critical aspect, and it can influence sustainability practices, resource conservation, and overall ecological well-being. Let's explore the environmental consequences in terms of sustainable practices, resource management, and the startup's eco-footprint:

1. **Sustainable Agricultural Practices:** The innovation capability of agro-based startups often leads to the adoption of sustainable agricultural practices. This includes the implementation of precision farming techniques, organic farming methods, and agroecological approaches. Precision agriculture, for example, involves the targeted use of resources such as water, fertilizers, and pesticides, optimizing their efficiency and minimizing environmental impact. Organic farming avoids synthetic inputs, promoting soil health and biodiversity. By incorporating such sustainable practices, startups contribute to the conservation of ecosystems and promote long-term environmental health.
2. **Resource Conservation:** Innovations in agro-based startups can contribute to resource conservation, addressing concerns related to water usage, soil degradation, and energy consumption. Water-efficient irrigation systems, soil conservation practices, and the use of renewable energy sources in farming operations exemplify how startups can reduce their environmental footprint. Additionally, the adoption of circular economy principles, where waste is minimized, recycled, or repurposed, further contributes to resource conservation and reduces environmental impact.
3. **Biodiversity and Ecosystem Health:** Agro-based startups, through their innovation capability, have the potential to positively impact biodiversity and overall ecosystem health. Practices that prioritize biodiversity conservation, such as agroforestry or the creation of wildlife habitats within agricultural landscapes, contribute to a more resilient and sustainable ecosystem. The protection and enhancement of biodiversity play a crucial role in maintaining ecological balance, pest control, and overall environmental stability.
4. **Carbon Footprint Reduction:** Innovations in agro-based startups can also address the challenge of carbon emissions associated with agriculture. Sustainable practices, such as cover cropping, agroforestry, and reduced tillage, can sequester carbon in the soil, mitigating the overall carbon footprint. Additionally, startups that invest in renewable energy sources for their operations or implement carbon offset initiatives contribute to the reduction of greenhouse gas emissions.
5. **Environmental Benefits for Startup Operations:** Agro-based startups can implement innovations that directly reduce their environmental impact. This may involve eco-friendly packaging, waste reduction strategies, and energy-efficient processing methods. Sustainable supply chain management, from farm to market, also contributes to reducing the environmental footprint of the overall operation. By prioritizing environmental responsibility, startups not only contribute to broader environmental conservation but also enhance their reputation and resilience in the market.

In conclusion, startups' innovation capability can potentially drive positive environmental outcomes. By adopting sustainable agricultural practices, conserving resources, promoting biodiversity, reducing carbon emissions, and incorporating eco-friendly measures in their operations, startups can contribute to a more sustainable and resilient agricultural ecosystem, benefitting both the environment and the long-term viability of their businesses.

**Digital Transformation in Agro Startups in India**

Digital transformation has revolutionized the agricultural landscape in India, with agro startups leveraging digital technologies to streamline processes, enhance productivity, and promote sustainability. Table 3 shows some digital transformation that are relevant in the field of agriculture. Digital platforms enable farmers to access real-time information on weather forecasts, market prices, and best agricultural practices, empowering them to make informed decisions and increase yields. Additionally, digital marketplaces connect farmers directly with buyers, eliminating intermediaries and ensuring fair prices for agricultural produce. Moreover, digital transformation fosters transparency and traceability in the agricultural supply chain, enhancing consumer trust and enabling ethical sourcing practices.

**Table 3: Digital Transformatio in the Field of Agriculture**

|  |  |  |
| --- | --- | --- |
| **S.no** | **Digital Transformation** | **Explaination** |
| 1 | Digital Market Platforms | Facilitate direct connections between farmers and buyers, reducing reliance on intermediaries and ensuring fair prices for agricultural produce |
| 2 | Precision Farming Solutions | Utilize data analytics and IoT sensors to optimize crop management practices, improving yields and resource efficiency. |
| 3 | Smart Irrigation Systems | Employ IoT technology to monitor soil moisture levels and weather forecasts, enabling precise water management and conservation. |
| 4 | Agri-Tech Mobile Applications | Provide farmers with access to agricultural inputs, expert advice, and market information, enhancing productivity and market access |
| 5 | Blockchain for Supply Chain Traceability | Utilize blockchain technology to create transparent and traceable supply chains, ensuring authenticity and ethical sourcing of agricultural products. |
| 6 | Farm Management Software | Digitize farm operations, including crop planning, inventory management, and financial tracking, enabling data-driven decision-making and efficiency. |
| 7 | Agri-Weather Forecasting | Deliver customized weather forecasts and agri-advisories to farmers, enabling informed decision-making and risk mitigation. |
| 8 | Livestock Management Solutions | Utilize IoT devices and AI algorithms to monitor livestock health and performance, improving overall herd management and productivity. |
| 9 | Agri-Finance Platforms | Offer digital financial services tailored to farmers' needs, including credit facilities, insurance products, and investment opportunities, fostering financial inclusion and resilience. |
| 10 | E-Marketplaces for Agri-Inputs | Provide online platforms for purchasing agricultural inputs such as seeds, fertilizers, and agrochemicals, enhancing convenience and accessibility for farmers. |

Here are some examples of digital transformation initiatives in agro startups in India

1. **AgriBazaar:** AgriBazaar is an online platform that connects farmers directly with buyers, eliminating middlemen and ensuring fair prices for agricultural produce. By digitizing the trading process, AgriBazaar facilitates transparent and efficient transactions, empowering farmers to access wider markets and achieve better price realization. Agribazaar was founded in 2016. It is currently at the scaling stage of startup development, having already achieved significant traction in the market and expanding its operations to reach a larger customer base.
2. **CropIn:** CropIn Technology Solutions offers digital solutions for precision farming, enabling farmers to optimize crop management practices through data-driven insights. CropIn was established in 2010. It has progressed beyond the early stages of startup development and is currently at the scaling stage.Their software platform utilizes satellite imagery, weather data, and soil analytics to provide personalized recommendations for crop planning, irrigation scheduling, and pest management, thereby improving yields and resource efficiency.
3. **Flybird:** FlyBird Farm Innovations is an agri-tech startup that was founded in 2013. It is currently at the early traction stage of startup development, having demonstrated the viability of its solutions and gaining momentum in the market. They has developed smart irrigation systems that utilize IoT sensors and cloud-based analytics to optimize water usage in agriculture. Their solution automatically adjusts irrigation schedules based on real-time data on soil moisture levels, weather forecasts, and crop water requirements, resulting in water savings and improved crop health.
4. **AgroStar:** AgroStar is an agri-tech company founded in 2013. It has progressed beyond the early stages of startup development and is currently at the scaling stage. AgroStar is a mobile application that provides farmers with access to agricultural inputs, expert advice, and market information. Through the app, farmers can purchase seeds, fertilizers, and pesticides, receive personalized crop advisories, and connect with agricultural experts for guidance on best practices. This digital platform enhances farmer productivity, reduces input costs, and improves market access.
5. **DeHaat:** DeHaat, founded in 2012, is an agri-tech startup that has advanced beyond the early stages of startup development and is currently at the scaling stage. It is one of India’s fastest growing agro-startup. The proposition offered by deHaat centers around providing end-to-end agricultural solutions to farmers through a technology-driven platform. Their digital platform offers a range of services including access to agricultural inputs, personalized crop advisories, market linkages, and financial assistance. By leveraging data analytics, AI algorithms, and a network of field experts, deHaat aims to empower farmers with knowledge, resources, and market access to enhance productivity and profitability. Additionally, deHaat's platform facilitates transparency and efficiency in the agricultural supply chain, contributing to sustainable and inclusive growth in the farming sector.
6. **FarmERP:** FarmERP is a comprehensive farm management software that helps farmers manage various aspects of their operations, including crop planning, inventory management, and financial tracking. The startup was incepted in 2001 and is said to be at the scale up stage. By digitizing farm data and providing analytics tools, FarmERP enables farmers to make data-driven decisions, optimize resource allocation, and improve overall farm efficiency.
7. **Skymet Weather Services:** Skymet Weather Services provides customized weather forecasts and agri-advisories to farmers through its digital platform. Founded in the year 2003 and is reaching maturity being India’s largest weather monitoring startup. By leveraging advanced weather modeling techniques and satellite imagery, Skymet delivers hyper-local weather forecasts, helping farmers plan their agricultural activities, minimize weather-related risks, and optimize crop management practices.
8. **MoooFarm:** nMoooFarm is an agri-tech startup that was founded in 2019. It is currently at the early traction stage of startup development. The proposition offered by MoooFarm revolves around providing digital solutions for dairy livestock management in farmers to improve productivity and profitability. Their mobile application offers a range of services including breed management, nutrition planning, and disease diagnosis.
9. **Jai Kisan:** Jai Kisan is an agri-tech startup founded in 2017. It is currently at the scaling stage of startup development. The proposition offered by Jai Kisan revolves around providing digital financial services to farmers. Their platform offers agricultural loans, insurance products, and other financial services tailored to the needs of farmers. By leveraging technology and data analytics, Jai Kisan aims to streamline the lending process, improve access to credit, and reduce the financial barriers faced by farmers. Additionally, Jai Kisan's platform may provide financial literacy and advisory services to help farmers make informed decisions and improve their financial management practices.
10. **AgroWave:** AgroWave is an e-commerce platform that specializes in selling agricultural inputs such as seeds, fertilizers, and agrochemicals established in the year 2017. It is at early traction stage. By digitizing the procurement process, AgroWave offers farmers a wide range of products, competitive pricing, and doorstep delivery, enhancing convenience and accessibility for farmers across rural India.

These examples highlight the diverse ways in which agro startups in India are harnessing digital technologies to transform the agricultural sector. By embracing digital transformation, these startups are driving innovation, increasing efficiency, and promoting sustainability, ultimately contributing to the modernization and growth of Indian agriculture.

**Conclusion**

In understanding the world of agro-based startups, this exploration concludes with a deep look into how these ventures innovate, impact the environment, show sustainability, and benefit from digital transformation.

It can be summarized that the innovation capability of the firm is a consequence of the internal dynamics and external dynamics of the organization. Internal dynamics include Entrepreneurial Orientation, Market Orientation, Learning Capacity, Organisational Structure, Inter-functional Coordination, and Employee Engagement. These internal dynamics are termed endogenous variables which serve as the core of innovation within these startups, driving their progress.

On the external front, factors such as Government Policies, Barriers to entry, Education and skill level, Technological Infrastructure, Demographic trends, Availability of Capital, and Trade Policy significantly influence the startup ecosystem. These external factors, known as exogenous variables, paint a broader picture of the environment in which these startups operate.

Transitioning from innovation to sustainability, three main dimensions come into focus: economic, societal, and environmental performance. Agro-based startups contribute to economic growth by creating jobs, stimulating local economies, and fostering financial stability. Socially, they empower communities, enhance healthcare and education, and catalyze positive transformations in rural livelihoods. Environmentally, startups are adopting sustainable practices to conserve resources, protect biodiversity, and mitigate climate change.

Moreover, the digital transformation of startups catalyzes progress in emerging markets. By leveraging digital technologies, agro-based startups enhance efficiency, improve market access, facilitate supply chain optimization, and empower stakeholders with data-driven insights. This digital transformation not only propels the growth of startups but also fosters inclusive development and resilience in emerging economies.

In summary, the success of agro-based startups is not merely profit-making, it entails a holistic approach that considers innovation, societal impact, environmental responsibility, and digital transformation. These startups are building a future where fields yield not only crops but also progress and sustainability, shaping a narrative of progress and responsibility intertwined.

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