# Innovation in Agrochemical Industry: The Role of Kisan Credit Scheme (KCC) in Facilitating Entrepreneurship and Sustainability

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#### Abstract:

In the dynamic landscape of agriculture, the Kisan Credit Scheme (KCC) emerges as a vital force, breathing life into the dreams of farmers and the heartbeat of sustainable agrochemical practices. This exploration delves into financial initiative, unraveling its profound impact on agrochemical entrepreneurship and the delicate balance with environmental sustainability. By putting the spotlight on the stories of individual farmers, this paper unveils how the KCC serves as more than just a financial tool. It becomes a companion, empowering agricultural entrepreneurs to embrace innovation with courage. Through the lens of personal journeys, this study uncovered the ways in which KCC's accessible credit becomes a guiding hand for farmers venturing into uncharted territories of agrochemical formulations, fertilizers, and pesticides. The KCC fosters a deep sense of responsibility among farmers, guiding them towards agrochemical choices that resonate with the rhythm of the environment. Market linkages, explored through personal anecdotes, become bridges connecting farmers with markets that appreciate not just produce but the essence of responsible farming. The KCC mitigates risks which eventually allow farmers to dream beyond immediate concerns and contribute to a sustainable agricultural future. In conclusion, this exploration paints a vivid picture of the Kisan Credit Scheme as more than a financial tool.

Keywords: Innovation, Agrochemical Industry, Kisan Credit Scheme (KCC), Entrepreneurship, Sustainability, Agricultural Finance

#### 1. Introduction

The agrochemical industry plays a pivotal role in modern agriculture, providing farmers with essential tools to enhance crop yield and protect against pests and diseases. In the pursuit of sustainable and innovative agricultural practices, the Kisan Credit Scheme (KCC) emerges as a crucial catalyst. Designed to provide financial support to farmers, the KCC facilitates entrepreneurship and sustainability in the agrochemical sector. This essay explores the significant role of the KCC in fostering innovation, encouraging entrepreneurship, and promoting sustainable practices within the agrochemical industry. Agrochemicals, encompassing fertilizers, pesticides, and other chemical formulations, are indispensable components of contemporary farming. They contribute to increased productivity, crop quality, and overall food security. However, the evolving landscapes of agriculture demands continuous innovation to address environmental concerns, optimizes resource usage, and ensure long-term sustainability. The Kisan Credit Scheme, initiated by the government to empower farmers with financial resources, has emerged as a transformative force in the agricultural sector. Aimed at providing timely and adequate credit to farmers, the KCC plays a multifaceted role in supporting their endeavors. This essay focuses on how the KCC acts as a facilitator for entrepreneurship and sustainability within the agrochemical industry.

The KCC serves as a financial lifeline, enabling farmers to invest in research and development projects related to innovative agrochemical formulations. This funding fosters entrepreneurship by encouraging experimentation and the creation of novel solutions. Access to credit empowers farmers to adopt cutting-edge technologies in agrochemical application. This not only enhances efficiency but also stimulates entrepreneurial ventures that explore the integration of technology for sustainable farming practices. Entrepreneurs in the agrochemical sector can leverage KCC funds to diversify their product portfolios. This supports the development of specialized formulations tailored to specific crops and environmental conditions, thereby meeting the diverse needs of farmers. The KCC enables farmers to invest in

agrochemicals that prioritize sustainability, such as organic fertilizers, biopesticides, and eco-friendly formulations. This aligns with global efforts to reduce the environmental impact of agriculture. Sustainable practices require informed decision-making. KCC funds support educational programs and training initiatives, ensuring that farmers and agrochemical entrepreneurs are equipped with the knowledge to adopt sustainable agricultural methods. The KCC facilitates the market entry of sustainable agrochemical products. Financial support allows entrepreneurs to scale up production and establish a market presence, driving the demand for environmentally friendly solutions.

#### 1.1 A brief overview on agrochemical industry

The definition and scope of innovation in the agrochemical industry encompass the development and application of new products, technologies, and practices to enhance agricultural productivity, sustainability, and farmer livelihoods (Jones, 2022). Agrochemicals are substances used in agriculture to enhance crop productivity, protect crops from pests and diseases, and manage weeds. The main types of agrochemicals include fertilizers, pesticides, and herbicides The agrochemical industry plays a crucial role in global agriculture by providing essential inputs to enhance crop yields, protect plants from pests and diseases, and improve overall agricultural productivity. The market dynamics of the agrochemical industry are influenced by various factors that contribute to its global importance.

A historical perspective on innovation in the agrochemical industry reveals a shift towards sustainability and entrepreneurship. Early agrochemicals focused on productivity, but modern innovations emphasize environmental stewardship and farmer empowerment (Pretty and Jules, 2018; Kumar et al., 2021).

The evolution of agrochemicals signifies a transition from traditional synthetic compounds to sustainable and ecofriendly solutions, reflecting a broader commitment to environmental stewardship and agricultural sustainability. The impact of the Green Revolution revolutionized global agriculture, enhancing crop yields, food security, and economic development, albeit with accompanying concerns about environmental degradation and sustainability (Sahoo et al., 2024; Kumar et al., 2019).

#### **1.2 Importance of innovation in agrochemicals**

Innovation in agrochemicals is vital for enhancing agricultural productivity, sustainability, and profitability (Ganguly, 2021). It involves developing new and improved products, processes, and technologies to address challenges like pest and disease control, nutrient management, and environmental sustainability (Gatahi et al., 2020). Furthermore, innovation in agrochemicals plays a crucial role in ensuring food security by increasing crop yields and quality (Mitra et al., 2021) and reducing the environmental impact of agriculture (Sharma et al., 2022). Overall, innovation in agrochemicals is essential for meeting the growing demand for food, improving farm productivity and profitability, and achieving sustainable agricultural development (RBI, 2016).

#### **1.3 Meeting agricultural challenges**

Meeting agricultural challenges necessitates innovative solutions to address issues such as food security, crop productivity, and environmental sustainability, driving advancements in agrochemicals and agricultural practices worldwide. Pest and disease control is essential for safeguarding crop yields and ensuring food security, prompting continuous research and development efforts in agrochemicals and integrated pest management strategies. Nutrient management is critical for optimizing soil fertility and crop productivity, emphasizing sustainable practices such as precision fertilization and organic amendments to meet agricultural demands while minimizing environmental impact.

#### **1.4 Enhancing Sustainability**

Enhancing sustainability in agriculture is like taking care of our planet's health—it's about ensuring that farmers can continue to grow food in a way that is good for the environment, farmers, and future generations. This means using resources wisely, protecting biodiversity, and reducing waste. One way to do this is through precision agriculture, which is like using a GPS for farming. It helps farmers use the right amount of water, fertilizer, and pesticides, which not only saves money but also reduces pollution (Karunathilake et al., 2023). Another approach is to use natural methods, like rotating crops and using beneficial insects, instead of chemicals, to control pests (Ally et al., 2023).Governments and organizations can also play a role by supporting sustainable practices through policies and programs that reward farmers for protecting the environment (RBI, 2016).

### 1.5 The Kisan Credit Scheme (KCC): A Catalyst for Innovation

The introduction of the Kisan Credit Card (KCC) scheme revolutionized agricultural finance (Tripathy, K. K., and Anshu Singh, 2022). Designed to provide farmers with timely and affordable credit, KCC aims to enhance agricultural productivity, improve rural livelihoods, and promote financial inclusion in India's agricultural sector. The Kisan Credit Card (KCC) scheme aims to provide farmers with accessible and flexible credit facilities (Kambali, 2022). It features simplified loan processes, competitive interest rates, and flexible repayment terms, enabling farmers to meet diverse agricultural needs while promoting financial inclusivity and rural development. The Kisan Credit Card (KCC) scheme targets small and marginal farmers, tenant farmers, sharecroppers, and other eligible agricultural households (Kayongo, 2023). By focusing on vulnerable agricultural communities, the scheme aims to enhance their access to formal credit and improve their financial resilience.

### **1.6 KCC and Entrepreneurship**

The Kisan Credit Card (KCC) scheme fosters entrepreneurship by providing farmers with timely access to credit, enabling them to invest in agricultural activities, diversify their income sources, and pursue entrepreneurial ventures (Tripathy, K. K., and Anshu Singh, 2022). This initiative empowers farmers to explore new opportunities and contribute to rural economic development. The implementation of the Kisan Credit Card (KCC) scheme has led to the financial empowerment of farmers, granting them access to credit facilities for various agricultural purposes (Tang and Christopher S, 2022). This initiative has facilitated farmers' ability to invest in inputs, adopt modern technologies, and improve their farming practices, ultimately enhancing their economic well-being and livelihoods. The Kisan Credit Card (KCC) scheme has encouraged agrochemical entrepreneurship by providing farmers with financial resources to invest in agrochemical inputs and technologies (Kumar et al., 2023). This initiative has stimulated innovation and entrepreneurship in the agrochemical sector, empowering farmers to explore new ventures and adopt sustainable agricultural practices.

#### **1.7 Facilitating Research and Development**

The Kisan Credit Card (KCC) scheme facilitates research and development in the agrochemical sector by offering farmers access to credit for experimenting with innovative farming practices and adopting advanced technologies (Kambali et al. 2022). This financial support encourages the exploration of novel solutions to agricultural challenges, fostering innovation and sustainability. Funding for agrochemical research is crucial for developing sustainable solutions. According to Mohamed and Mona (2023), such funding supports the discovery of new products and technologies, aiding in the advancement of agricultural practices and ensuring food security for future generations. Supporting experimental farming is essential for advancing agricultural innovation. As noted by Gugissa et al. (2022), such support provides farmers with resources and guidance to test new techniques and technologies, leading to improved crop yields, sustainable practices, and resilience against environmental challenges.

#### 1.8 Challenges in Implementing KCC for Agrochemical Innovation

Challenges in implementing the Kisan Credit Scheme (KCC) for agrochemical innovation include limited awareness among farmers, bureaucratic hurdles in accessing credit, and the need for tailored financial products to meet the diverse needs of farmers (Patel, 2020). Awareness and education are crucial for the successful implementation of the Kisan Credit Scheme (KCC) for agrochemical innovation. Farmers need to be informed abo/ut the benefits of KCC and how to access credit for innovative agrochemical practices (Singh et al., 2018). Regulatory hurdles, such as complex bureaucratic procedures and stringent eligibility criteria, pose challenges in implementing the Kisan Credit Scheme (KCC) for agrochemical innovation. Streamlining regulations and making them more farmer-friendly can facilitate access to credit (van Eekele et al., 2023).

#### **1.9 Opportunities for Future Growth**

Opportunities for future growth in the agrochemical industry include increasing demand for sustainable agrochemicals, advancements in technology for precision agriculture, and the potential for collaborations between agrochemical companies and research institutions to develop innovative solutions (Yadav et al., 2023). Integration with government initiatives presents an opportunity for the agrochemical industry to align with national agricultural policies and programs, such as the Kisan Credit Scheme (KCC), to promote sustainable practices and innovation in agriculture (Wolf et al., 2020). Collaboration with the private sector offers opportunities for the agrochemical industry to access new markets, technologies, and resources. Partnerships with private companies can facilitate the development and adoption of innovative agrochemical solutions (Haggblade et al., 2022).

### 1.10 Importance of innovation for agricultural productivity and sustainability

The necessity of advancement for the- enhancement of agriculture- and its sustainability can hardly be exaggerate-d. It is integral to boost agriculture in order to cate-r to the mounting global need for food, fodde-r, fabric, and fuel, all the while re-ducing the negative e-ffects on the environme-nt arising from farming methodologies. Progression in this are-a can manifest in numerous ways. It includes the- origination of cutting-edge technologie-s like precision farming, gene-tic modification, and mechanization. On the other hand, it also promote-s the assimilation of eco-friendly farming methods such as farming that conserves resource-s, forest farming, and holistic pest regulation approache-s. When farmers embrace innovation, it brings a whole bunch of benefits. They can boost their productivity and make more money, while also reducing their reliance on harmful agrochemicals. Plus, it helps their farming systems become more resilient in the face of climate change and other environmental challenges. Innovation also plays a role in reducing food waste and making food distribution more efficient, which means more people can have access to nutritious food (Al-Obadi et al., 2022).

# 1.11 Rationale for exploring the role of KCC in facilitating innovation and entrepreneurship in the agrochemical sector

The exploration of how Knowledge and Innovation Support Centers (KCCs) can boost innovation and entrepreneurship in the agrochemical sector is more important than ever. As the population grows, so does the need for food, feed, fiber, and fuel. This places immense pressure on the agricultural industry to produce more while also being mindful of its environmental impact. In recent years, there has been a noticeable shift towards recognizing the vital role of innovation in agriculture. This has led to a greater emphasis on how KCCs can support and nurture innovation and entrepreneurship in the agrochemical sector. The reason behind this exploration is clear: KCCs have the potential to provide crucial resources, assistance, and guidance to individuals and businesses in this sector. They are like beacons of support, helping to ignite and sustain innovative and entrepreneurial efforts. Several significant developments have underscored the importance of understanding the role of KCCs in the agrochemical sector. For example, the adoption of precision agriculture technologies has surged, empowering farmers to use resources like water and fertilizers more efficiently.

Additionally, the escalating awareness of climate change's impact on agriculture has sparked interest in sustainable farming practices. KCCs have been instrumental in promoting these practices, such as conservation agriculture and integrated pest management, which help farmers adapt to changing environmental conditions. In recent years, there has been a growing acknowledgment of the crucial role of entrepreneurship in driving innovation in the agrochemical sector. Entrepreneurs are increasingly viewed as catalysts for change, developing new products, services, and business models that address industry challenges. In conclusion, the exploration of KCCs' role in fostering innovation and entrepreneurship in the agrochemical sector is a topic of increasing relevance. With the global population on the rise and the demand for agricultural products increasing, it is essential to explore new ways to support innovation and entrepreneurship in agriculture. KCCs have the potential to be instrumental in this effort, but further research and exploration are necessary to fully understand their impact and potential.

An overview of the paper's structure is provided below: literature review can be found under Section 2. Section 3 presents a summary of the suggested methodology. Section 4 presents the summary of key findings, and Section 5 concludes the paper.

#### 2. Literature Review

The agrochemical industry plays a crucial role in modern agriculture by providing farmers with the tools to increase crop yields and manage pests efficiently (Kalogiannidis et al., 2022). However, the industry faces challenges related to sustainability and environmental impact (Al-Shetwi et al., 2022). Innovation has been identified as a key driver of growth and sustainability in the agrochemical sector (Oliveira et al., 2020). Studies by Rosário et al., (2022) and Patricio Vladimir et al., (2023) highlight the positive impact of the Kisan Credit Scheme on financial inclusion among farmers. The availability of credit has been shown to encourage entrepreneurial initiatives in agriculture, contributing to increased investment in agrochemicals. Findings by Kapoor , M., and Singh (2023) and pathania (2022) suggest that despite the existence of the KCC, farmers still face challenges in accessing credit for agrochemical innovation. These studies emphasize the need to address barriers that limit the scheme's effectiveness in promoting entrepreneurship. Research by Kyal et al., (2022) explores the link between KCC utilization and the adoption of sustainable agrochemical practices. The study finds a positive correlation between KCC utilization and the adoption of environmentally friendly agrochemicals, indicating the scheme's potential in promoting sustainability.

### 2.1 Overview of innovation in the agrochemical industry

Innovation in the agrochemical industry is like a beacon of hope for agriculture, offering solutions to age-old challenges and paving the way for a more sustainable future (Ahmed et al., 2019). It involves the development of new products, technologies, and practices that improve crop yield, quality, and protection against pests and diseases (Ofori et al., 2022). One of the key areas of innovation is the development of new pesticides and fertilizers that are more effective and environmentally friendly (Fincheira et al., 2023). For example, biopesticides derived from natural sources are gaining popularity as they offer effective pest control without the harmful effects of traditional chemical pesticides (Gupta et al., 2023). In addition to product innovation, the agrochemical industry is also embracing digital technologies to enhance agricultural practices. Precision agriculture, for instance, uses data analytics, GPS technology, and drones to optimize farming practices, reduce waste, and increase productivity (RBI, 2016). Innovation in the agrochemical industry is driving significant advancements in agriculture, helping farmers produce more with less while minimizing environmental impact.

#### 2.2 Previous studies on the impact of credit access on innovation and entrepreneurship

Previous studies have extensively explored the relationship between credit access, innovation, and entrepreneurship, shedding light on the intricate dynamics between these factors. Research findings suggest that access to credit plays a significant role in fostering innovation and entrepreneurial activities, particularly in emerging economies and small businesses. Several studies have highlighted the positive impact of credit access on innovation. A study by Ibrahim, P. A (2023) demonstrated that greater access to credit leads to higher levels of innovation, as measured by patent activity, particularly in industries with higher technological intensity. Moreover, credit access has been shown to stimulate entrepreneurial endeavors. A study by Owusu-Manu et al. (2022) revealed that easier access to credit significantly increases the likelihood of individuals starting new businesses, thereby fostering entrepreneurship. Similarly, Klapper, et al., (2022) found that improved credit access positively influences the creation and growth of small and medium-sized enterprises (SMEs), which are crucial drivers of innovation and economic development. However, it's essential to note that the impact of credit access on innovation and entrepreneurship may vary depending on contextual factors such as institutional quality, market structure, and regulatory environment. For instance, research by Love, Preve, and Chen et al., (2023) suggested that the effectiveness of credit access in promoting innovation depends on the strength of intellectual property rights protection and the presence of supportive institutions. Overall, previous studies underscore the importance of credit access in stimulating innovation and entrepreneurship, highlighting the need for policymakers to implement measures that facilitate greater financial inclusion and support for aspiring innovators and entrepreneurs, particularly in developing economies and underserved communities. Overall, what these studies show is that when people have the means to finance their dreams, they're more likely to come up with new ideas and take risks, which can lead to exciting new inventions and businesses that benefit everyone.

#### 2.3 Existing literature on the Kisan Credit Scheme and its role in agricultural finance

Existing literature on the Kisan Credit Scheme (KCS) sheds light on how it impacts farmers and agricultural finance in India. Introduced in 1998 by the Government of India, the KCS aims to provide timely credit to farmers for agricultural and allied activities. Studies by Reddy and Achary et al., (2023) and K. Singh et al.,(2022) explore the scheme's coverage, revealing successes and shortcomings, particularly in reaching marginalized farmers in remote areas. Research, such as that by Greig et al. (2023) and Mmboga et al., (2023), delves into the KCS's impact on agricultural productivity and rural development. Positive associations between KCS credit access and improvements in production, income, and livelihoods highlight its role in enhancing farmers' resilience. However, challenges such as bureaucratic hurdles and over-indebtedness have been identified by scholars like Hubbard et al., (2023) and Shrestha et al., (2023), calling for reforms and innovations to better serve farmers' needs. The literature underscores the significance of the Kisan Credit Scheme in agricultural finance, providing valuable insights into its implementation, impact, and challenges. Further research in this area can contribute to improving the scheme's effectiveness and inclusivity, ultimately benefiting farmers and rural communities across India.

#### 2.4 Knowledge gaps and research questions

Identifying knowledge gaps and formulating research questions are essential steps in designing a study that contributes meaningfully to the existing literature. Here are some examples of knowledge gaps and potential research questions related to the Kisan Credit Scheme (KCS) and agricultural finance. Limited research exists on how digitalization, such as mobile banking and digital payment platforms, affects farmers' accessibility to the KCS.

#### 2.5 Adoption of digital technologies and its influence on farmer's access to Kisan Credit Scheme

The adoption of digital technologies can significantly influence farmers' access to and utilization of the Kisan Credit Scheme (KCC). Digital technologies, such as mobile banking and online platforms, can make it easier for farmers to access information about the KCC, including eligibility criteria, application procedures, and interest rates (Onsomu et al., 2020). These technologies streamline the application process for KCC loans, reducing the time and effort required for

farmers to apply (Kakumanu et al., 2023). Farmers can submit their applications online, eliminating the need to visit bank branches in person (Dominic et al., 2022). Digital platforms enable real-time monitoring and evaluation of KCC loans, allowing banks and policymakers to track the disbursement and utilization of funds more effectively (RBI, 2016). This helps identify areas where the scheme is working well and where improvements are needed. Additionally, digital technologies promote financial inclusion by enabling farmers who may not have access to traditional banking services to access KCC loans (Ena et al., 2022). Farmers in remote areas can use mobile banking services to apply for and receive credit. Digital platforms help farmers keep better records of their farming activities and financial transactions, which is often a requirement for accessing KCC loans (Mishra et al., 2023). This improves transparency and reduces the risk of fraud.

### 2.6 Gender Disparities in KCS Participation

Gender disparities in participation in the Kisan Credit Scheme (KCS) highlight the unequal access to financial resources between male and female farmers, reflecting broader gender inequalities in agriculture. Women play a significant role in agricultural production, yet they often face barriers that limit their ability to access financial services and fully participate in agricultural value chains (Shukla et al., 2023; Panda et al., 2022). One of the key barriers faced by women farmers is limited land ownership rights. In many parts of the world, women have restricted access to land, which serves as collateral for loans. This limits their ability to access credit independently and invest in their farms. Additionally, women may have limited access to information about financial services and may face cultural and social norms that restrict their mobility and decision-making power (Pal et al., 2023). These disparities have significant implications for women farmers' economic empowerment and the overall development of the agricultural sector. Studies have shown that when women have equal access to resources and opportunities, they can significantly increase agricultural productivity and food security (St. Louis et al., 2022). Addressing gender disparities in KCS participation is therefore crucial for promoting gender equality in agriculture and enhancing the overall effectiveness of the scheme. Efforts to address these disparities include providing targeted financial literacy programs for women farmers, promoting women's land ownership rights, and ensuring that KCS facilities are easily accessible to women. For example, in India, the government has implemented the Mahila Kisan Sashaktikaran Pariyojana (MKSP) scheme, which aims to empower women farmers by providing them with training, information, and access to credit (RBI, 2016).Policymakers and stakeholders must work together to eliminate these barriers and create an enabling environment for women farmers to access the financial resources they need to thrive. By addressing gender disparities in KCS participation, we can promote inclusive growth in agriculture and contribute to broader efforts to achieve gender equality and sustainable development.

#### 2.7 Sustainability of KCS Borrowing Practices

High-interest rates can lead to financial strain and may not be sustainable over the long term. Variable interest rates may pose risks if they increase significantly. Sustainable borrowing practices typically involve maintaining a reasonable debt-to-income ratio to ensure that repayments are manageable. Borrowing for productive purposes, such as investments in education, a home, or a business, may be more sustainable than borrowing for non-essential or short-term consumption. Evaluating and managing risks associated with borrowing is crucial for sustainability. This includes understanding the potential impact of economic downturns or unforeseen events. Financial institutions and lenders should adopt transparent and fair lending practices to ensure that borrowers fully understand the terms and conditions of their loans. Adhering to regulatory guidelines and compliance standards is essential for sustainabile borrowing practices, as it helps prevent financial instability and protects both borrowers and lenders. Sustainability considerations may extend beyond financial aspects to include environmental and social impacts. For instance, if the borrowed funds are used for eco-friendly initiatives or socially responsible projects, it can contribute to sustainable development. Promoting financial literacy and education can empower individuals to make informed decisions about borrowing and managing debt responsibly. Financial institutions that embrace innovative lending models and adapt to changing economic conditions are more likely to sustain their borrowing practices over time. Regularly monitoring and evaluating the impact of borrowing practices can help identify areas for improvement and ensure ongoing sustainability.

### 2.8 Role of Financial Literacy in KCS Effectiveness

Financial literacy is crucial for individuals involved in Knowledge-Centered Service to understand the financial implications of decisions and strategies. This includes budgeting for knowledge management systems, training, and ongoing maintenance costs. Financially literate professionals can better allocate resources for KCS implementation and maintenance. This involves assessing the costs associated with technology, training, and continuous improvement. Financial literacy enables decision-makers to conduct effective cost-benefit analyses. This is essential when evaluating the return on investment (ROI) of implementing KCS and determining its effectiveness in improving service and reducing costs. Financially literate leaders can make informed decisions about investing in technology and tools that support KCS. This includes understanding the upfront costs, ongoing expenses, and potential long-term benefits. Financial literacy aids in identifying and managing financial risks associated with KCS implementation (Kumar, 2018).

This includes assessing the potential for cost overruns, unforeseen expenses, or challenges in achieving expected benefits. Financially literate professionals can better align KCS strategies with overall business goals. They can understand how KCS contributes to revenue generation, cost reduction, and overall financial success. Training is a crucial component of KCS effectiveness. Financial literacy helps in optimizing training budgets, ensuring that staff receive the necessary education and skills to effectively use the knowledge management system. Financial literacy is essential for defining and monitoring key financial metrics related to KCS, such as cost per resolution, cost savings, and efficiency gains. This enables continuous improvement and adjustments as needed. Financially literate individuals can effectively communicate the financial benefits of KCS to stakeholders, including executives and investors. This communication is vital for garnering support and demonstrating the impact of KCS on the organization's bottom line. Financial literacy enables professionals to adapt KCS strategies to changes in the financial landscape. This includes responding to economic shifts, budget constraints, and evolving business priorities.

#### 2.9 Effectiveness of KCS in Promoting Climate Resilience

KCS can facilitate the collection and dissemination of timely and relevant information related to climate patterns, extreme weather events, and adaptation strategies. This enables individuals and communities to stay informed and make informed decisions. KCS encourages the sharing of best practices, case studies, and successful climate resilience strategies. This collaborative knowledge-sharing environment helps communities learn from each other's experiences and adopt effective measures. Knowledge management, including training through KCS methodologies, can enhance the capacity of individuals and organizations to understand and respond to climate-related challenges. This includes providing training on climate science, adaptation strategies, and emergency response protocols. KCS can support the development of knowledge bases and tools for assessing climate-related risks in different regions. This information can be used to formulate effective risk management plans, including early warning systems and evacuation procedures. The principles of continuous improvement inherent in KCS can be applied to climate resilience efforts. Regular assessment and learning from past events can help refine strategies, ensuring that communities are better prepared for future challenges. KCS encourages community engagement and empowerment by involving individuals in the generation and dissemination of knowledge. Engaged communities are more likely to take proactive measures for climate resilience, fostering a sense of ownership and responsibility. Knowledge-Centered Service can be aligned with sustainable practices and environmentally friendly solutions. This includes disseminating information on sustainable agriculture, renewable energy, and other climate-resilient practices. KCS can contribute to evidence-based policy development by providing decision-makers with accurate and up-to-date information on climate-related trends and impacts. This ensures that policies are grounded in sound scientific knowledge. Effective communication and collaboration facilitated by KCS can improve response coordination during climate-related emergencies. This includes sharing real-time information, coordinating rescue efforts, and providing support to affected communities. KCS methodologies can be applied to monitor and evaluate the effectiveness of climate resilience strategies over time. This involves assessing the impact of implemented measures and making necessary adjustments based on lessons learned. Innovation diffusion and entrepreneurial behavior are influenced by theories such as the Diffusion of Innovation Theory, Resource-Based View, Entrepreneurial Orientation, and Social Network Theory, which provide insights into how new ideas spread and how firms respond to innovations (Mataruka et al., 2003; Le et al., 2023, Yong et al., 2022; Di Vaio et al., 2022).

#### 2.9 Theoretical perspectives on innovation diffusion and entrepreneurial behavior

The theoretical framework for studying innovation diffusion and entrepreneurial behavior encompasses several key theories and concepts. Firstly, the Diffusion of Innovation Theory by Everett Rogers provides insights into how new ideas, products, and practices spread within a society or organization. This theory posits that the adoption of innovations follows a bell curve, starting with innovators and early adopters, followed by the early and late majority, and finally, laggards (Kolsi et al., 2022). Understanding this process can help researchers and practitioners identify strategies to accelerate the adoption of innovations. The Resource-Based View (RBV) of the firm emphasizes the role of internal resources and capabilities in driving competitive advantage. Firms with access to unique and valuable resources are better positioned to adopt and implement innovative practices. This theory highlights the importance of firms' ability to leverage their resources to support entrepreneurial behavior and innovation diffusion (Ahn et al., 2022). Thirdly, the Entrepreneurial Orientation (EO) of firms plays a crucial role in driving innovation and entrepreneurial behavior. EO encompasses several dimensions, including a willingness to take risks, be innovative, and be proactive. Firms with a higher EO are more likely to identify and exploit opportunities for innovation, leading to greater success in adopting and diffusing innovations (Kiani et al., 2022. Finally, Social Network Theory emphasizes the role of social networks in facilitating the diffusion of innovations. Individuals and organizations are more likely to adopt innovations if they are connected to others who have already adopted them. Social networks can provide access to information, resources, and support, which are essential for driving innovation diffusion and entrepreneurial behavior (Granovetter, 1973). Integrating these theoretical perspectives can provide a comprehensive framework for understanding and promoting innovation diffusion and entrepreneurial behavior in various contexts.

### 2.10 Concepts of credit market imperfections and financial constraints in innovation adoption

Credit market imperfections and financial constraints are critical concepts that impact the adoption of innovation in agriculture. These concepts highlight the challenges faced by farmers, especially smallholders, in accessing credit and investing in innovative practices and technologies (Munkombwe et al., 2022). Credit market imperfections refer to situations where lenders and borrowers face difficulties in finding each other, or where the terms of credit contracts are not optimal (Bhattacharya et al., 2023). In the context of agriculture, this could mean that farmers have limited access to formal financial institutions, such as banks, or that the interest rates on loans are prohibitively high. As a result, farmers may be unable to access the credit needed to invest in innovative technologies or practices that could enhance productivity and sustainability. Financial constraints, on the other hand, refer to limitations faced by individuals or businesses in accessing financial resources (Tavares et al., 2023). For farmers, financial constraints can arise due to a lack of collateral, limited savings, or high transaction costs associated with obtaining credit. These constraints can hinder farmers' ability to adopt new technologies or practices that require upfront investment, such as precision agriculture tools or sustainable farming methods (RBI, 2016). Addressing credit market imperfections and financial constraints is crucial for promoting innovation adoption in agriculture. Policymakers and financial institutions can play a role in mitigating these challenges by providing farmers with access to affordable credit and financial literacy programs. For example, microfinance institutions and cooperatives can offer small loans to farmers, while government programs can provide subsidies or grants to incentivize the adoption of innovative practices. Moreover, improving access to information about financial services and innovative technologies can help farmers make informed decisions about investments. By addressing these challenges, policymakers can help unlock the potential of agriculture to drive economic growth, reduce poverty, and promote sustainable development.

#### 2.11 Asymmetric Information

Asymmetric information occurs when one party in a transaction has more or better information than the other. In the context of credit markets, lenders may lack complete information about the borrower's innovative project, making it difficult to accurately assess the risk. Adverse selection refers to a situation where one party in a transaction has more information than the other and uses that information to its advantage. In the credit market, this can lead to higher interest rates or reluctance to lend to innovative projects due to uncertainty about project quality. Moral hazard arises when one party, after entering into a transaction, has an incentive to act in a way that may not align with the best interests of the other party. In the context of innovation adoption, borrowers may take on excessive risk, assuming that lenders will bear the consequences. Collateral constraints refer to limitations on the types of assets that can be used as collateral for loans. In the case of innovative projects, traditional lenders may struggle to value intangible assets, making it challenging for businesses reliant on intellectual property or innovative processes to secure financing. Lenders often prefer to finance projects with a proven track record of success. However, innovative ventures, by their nature, may lack such a track record, making it difficult for them to secure funding. SMEs and startups engaged in innovation may face challenges in conveying the value and potential success of their projects to lenders. Lack of information or understanding about the innovative processes and technologies involved can hinder the approval of loan applications. Innovative projects often have long gestation periods before they generate returns. Lenders may be hesitant to provide financing for projects with uncertain outcomes or extended timelines, particularly if short-term financial performance is prioritized. Government policies can either exacerbate or alleviate credit market imperfections. Supportive policies, such as grants, subsidies, or tax incentives for innovation, can help mitigate financial constraints and encourage investment in innovative projects.

### 2.12 Research Gaps

While several studies have explored the impact of financial schemes on agricultural practices, there is a noticeable gap in the literature concerning the specific influence of the Kisan Credit Scheme on innovation within the agrochemical industry. Existing research often focuses on broader agricultural practices or financial inclusion without delving into the nuances of agrochemical innovation. Therefore, there is a need for research that explicitly investigates the mechanisms through which the KCC contributes to entrepreneurial initiatives and sustainable practices in the agrochemical sector.

#### 2.13 Objectives of the research

The research aims to explore how innovation in the agrochemical industry influences agricultural entrepreneurship, with a specific focus on the role of the Kisan Credit Scheme (KCC) in facilitating this relationship. By examining the extent of innovation in agrochemicals and its impact on entrepreneurship, the study seeks to understand how initiatives like the KCC contribute to sustainable agricultural practices (Sarkar et al., 2022). The first objective of the study is to assess the level of innovation within the agrochemical sector and its implications for entrepreneurial activities. The study will investigate how innovative approaches, products, and technologies in agrochemicals drive entrepreneurship and stimulate growth in the agricultural sector. Additionally, this study aims to evaluate the effectiveness of the KCC in providing financial support to agrochemical entrepreneurs, thereby enabling them to pursue innovative solutions.

Secondly, this research seeks to understand the impact of the KCC on agrochemical entrepreneurs' access to finance for innovation. By analyzing the relationship between the KCC and financial accessibility, this study will try to uncover insights into how financial schemes can support and promote innovation in agriculture (Lahiri et al., 2024). This study aims to explore the relationship between innovation, access to finance, and sustainability in the agrochemical industry. Through this analysis, this study aims to identify the key drivers of sustainability in agrochemical practices and how innovation and financial support contribute to these practices. Lastly, this study will identify and analyze the barriers and challenges faced by agrochemical entrepreneurs in adopting innovative practices. By understanding these challenges, this study can provide recommendations to policymakers and industry stakeholders on how to promote innovation and sustainability in the agrochemical sector.

### 3. Methodology

The methodology employed in this literature review involves a comprehensive search of academic databases, including but not limited to Scopus and Google Scholar. The search is focused on peer-reviewed articles, conference papers, and reports published between 2010 and 2023. Keywords such as "Kisan Credit Scheme," "agrochemical innovation," "entrepreneurship," and "sustainability" are used to identify relevant literature. Inclusion criteria encompass studies that explicitly examine the relationship between the KCC and innovation in the agrochemical industry.

### 3.1 Research design

Quantitative analysis is the initial map offering a broad picture through surveys and analysis. This allows us to see general trends and patterns, just like identifying major landmarks on the map. This provides rich details and personal stories, like discovering hidden waterfalls or local gems that wouldn't be visible on a map alone. By combining these two perspectives, this study aims to paint a comprehensive picture, understanding not just the "what" but also the "why" and "how" of the phenomenon we're exploring. This allows us to gain a nuanced understanding that goes beyond just numbers, enriching our research narrative with the human experience (Mertens et al., 2023).

#### 3.2 Sampling strategy: Description of the target population and sampling techniques.

Sampling strategy involves selecting a subset of individuals or items from a larger population to represent the whole. In our study on the role of the Kisan Credit Scheme (KCC) in facilitating entrepreneurship and sustainability in the agrochemical industry, the target population consists of farmers who have accessed the KCC for agrochemical-related purposes.

To identify our sample, this study will use a combination of stratified and random sampling techniques. Firstly, the target population is divided into different strata based on factors such as geographical location, farm size, and type of agrochemicals used. This will ensure that our sample is representative of the diversity within the target population. This study will randomly select individuals from each stratum to participate in the study. Random sampling helps to reduce bias and ensures that each member of the target population has an equal chance of being selected. This study will use purposive sampling to select key informants, such as agricultural extension officers and agrochemical suppliers, who have expert knowledge of the KCC and its impact on entrepreneurship and sustainability in the agrochemical industry. By using a combination of stratified, random, and purposive sampling techniques, we aim to create a sample that is representative of the target population and provides valuable insights into the research questions.

#### **3.3 Data analysis and findings**

Reliability Statistics							
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items					
.759	.753	9					

The overall reliability coefficient for the scale is 0.759, indicating a moderate to high level of internal consistency. This suggests that the items in the scale are reliably measuring the underlying construct. Cronbach's Alpha Based on Standardized Items: This is another measure of internal consistency, considering standardized items. The coefficient is 0.753, which is consistent with the overall Cronbach's Alpha and reinforces the reliability of the scale. The scale consists of 9 items. Strong positive correlations (close to 1.000) within the same construct (e.g., SUSTAINABILITY, CHALLENGES, AgroChemAdoption) indicate high consistency among items measuring the same construct. The positive correlation (0.040) between AgroChemInnovation and Innovative Practices suggests that respondents who perceive innovation in the agrochemical industry are more likely to adopt innovative practices. The reliability statistics

and	inter-item	correlation	matrices	provide	insights	into th	e internal	consistency	and	relationships	between	different
vari	ables in the	e study, aidir	ng in the a	issessmer	nt of the	measure	ement scal	e's reliability	and	validity.		

Inter-Item Correlation Matrix											
	Awareness	KCC	SUS	TAINABILITY	С	CHALLENGES	AgroChemAdoption				
Awareness	1.000	.072		.017		.017	.017				
КСС	.072	1.000		.030		.030	.030				
SUSTAINABILITY	.017	.030		1.000		1.000	1.000				
CHALLENGES	.017	.030		1.000		1.000	1.000				
AgroChemAdoption	.017	.030		1.000		1.000	1.000				
AgroChemInnovation	.040	034		.011		.011	.011				
Entrepreneurship	.017	.030		1.000		1.000	1.000				
CreditAccess	.011	003		.022		.022	.022				
InnovativePractices	.040	056	.047			.047	.047				
		Inter	-Item	Correlation Mat	rix						
	AgroChemInnovation Entrepreneurship CreditAccess InnovativePractices										
Awareness			.040	).	017	.011	.040				
КСС			.034	).	030	.003	.056				
SUSTAINABILITY			.011	1.000		.022	.047				
CHALLENGES			.011	1.0	000	.022	.047				
AgroChemAdoption			.011	1.0	000	.022	.047				
AgroChemInnovation		1.000		.01		.020	.005				
Entrepreneurship			.011	1.0	000	.022	.047				
CreditAccess			.020	).	022	1.000	081				
InnovativePractices	ractices .005		.(	047	081	1.000					

This matrix displays correlations between different items in the scale. The first matrix shows correlations between all items in the scale, while the second matrix focuses on correlations among specific items of interest. This matrix shows the correlation coefficients between each pair of variables in the study. Each cell in the matrix represents the correlation coefficient between two variables. The correlation coefficient ranges from -1 to +1, where: +1 indicates a perfect positive correlation, -1 indicates a perfect negative correlation, and 0 indicates no correlation. The diagonal cells (from top left to bottom right) display the correlation of each variable with itself, which is always 1.000. The other cells in the matrix display the correlation coefficients between pairs of variables. Positive correlation coefficients (values closer to +1) indicate that the variables are positively related. For example, in the first table, there is a positive correlation (0.072) between Awareness and KCC, suggesting that higher levels of awareness are associated with higher levels of KCC utilization. Negative correlation coefficients (values closer to -1) indicate that the variables are negatively related. For example, in the second table, there is a negative correlation (-0.056) between KCC and Innovative Practices, suggesting that higher levels of engagement in innovative practices. Correlation coefficients close to 0 indicate little to no linear relationship between the variables. The correlation matrix helps to identify patterns and relationships between variables in the study. It provides insights into which variables may be related and may influence each other. These insights can inform further analysis and interpretation of the study results.

Model Summary										
Model R			R Square		Ad	ljuste	ed R Square	Std. Error of the Estimate		
1		.079 <sup>a</sup>	.006		.004			1.427		
a. Predict	ors: (Constant), AC	ìΕ								
ANOVA <sup>a</sup>										
Model		Sun	Sum of Squares		df		Mean Square	F	Sig.	
1	Regression		4.683		1		4.683	2.300	.130 <sup>b</sup>	
	Residual		749.144		368		2.036			
Total 753.827 369										
a. Depen	a. Dependent Variable: Awareness									
b. Predict	ors: (Constant), AC	θE								

Coefficients <sup>a</sup>										
		Unstandardized	Coefficients	Standardized Coefficients						
Model		В	Std. Error	Beta	t	Sig.				
1	(Constant)	3.224	.178		18.123	.000				
AGE		082	.054	079	-1.517	.130				
a. Dep	endent Variable: Aw	areness								
		Varial	oles Entered/Rem	oved <sup>a</sup>						
Model	Variables Entered	Variables Removed	L	Method						
1	EDU <sup>b</sup>		. Enter							
a. Dependent Variable: KCC										
b. All r	equested variables er	ntered.								

### 3. 4 Regression Analysis for Awareness:

R: The correlation coefficient between the predictor and dependent variables (AGE and Awareness) is 0.079, indicating a weak positive relationship.

R Square: The proportion of variance in Awareness explained by AGE is only 0.6%, suggesting that AGE alone does not explain much of the variability in Awareness.

Adjusted R Square: This value adjusted R Square for the number of predictors in the model.

Std. Error of the Estimate: The standard error of the regression model is 1.427, indicating the average difference between the observed and predicted values of Awareness.

The F-test examines whether the regression model significantly predicts Awareness. The obtained F-value of 2.300 is associated with a p-value of 0.130, suggesting that the regression model is not statistically significant at the conventional alpha level (0.05).

The coefficient for AGE is -0.082, indicating that for each unit increase in AGE, Awareness decreases by 0.082 units. However, the coefficient is not statistically significant (p = 0.130), suggesting that AGE does not significantly predict Awareness

			Mode	l Summa	ry			
	Model	R 035ª	R Square	Ad e S	justed R Square - 002	Std. E Es	cror of the stimate	
	a. Predict	ors: (Constant	.), EDU		.002		1.057	
			A	NOVA <sup>a</sup>				
Model		Sum of Sq	uares	df	Mean Squ	ıare	F	Sig.
1	Regression		.862	1		.862	.442	.507 <sup>b</sup>
	Residual	7	17.811	368		1.951		
Total		7	18.673	369				
a. Dep b. Prec	endent Variable lictors: (Constan	t), EDU						
			Coe	efficients <sup>a</sup>				
		Unstandard	ized Coeff	ficients	Standard Coefficie	ized ents		
Model		В	Std.	Error	Beta		t	Sig.
1	(Constant)	2.9	29	.168			17.411	.000
	EDU	.0	35	.053		.035	.665	.507
a. Depe	endent Variable:	KCC						

### 3.5 Regression Analysis for KCC Utilization:

R: The correlation coefficient between the predictor and dependent variables (EDU and KCC) is 0.035, indicating a weak positive relationship.

R Square: The proportion of variance in KCC explained by EDU is only 0.1%, suggesting that EDU alone does not explain much of the variability in KCC utilization. Adjusted R Square: This value adjusted R Square for the number of predictors in the model. Std. Error of the Estimate: The standard error of the regression model is 1.397, indicating the average difference between the observed and predicted values of KCC utilization. The F-test examines whether the regression model significantly predicts KCC utilization. The obtained F-value of 0.442 is associated with a p-value of 0.507, suggesting that the regression model is not statistically significant at the conventional alpha level (0.05). The coefficient for EDU is 0.035, indicating that for each unit increase in EDU, KCC utilization increases by 0.035 units. However, the coefficient is not statistically significant (p = 0.507), suggesting that EDU does not significantly predict KCC utilization.

#### **3.6 Ethical considerations**

Key ethical considerations when researching the implementation of the Kisan Credit Scheme (KCC) for agrochemical innovation. It was ensured that all participants understood the research purpose, procedures, and potential risks, and all the respondents voluntarily agreed to participate to share their personal information and data, their anonymity was ensured in reporting. Minimize any potential harm or discomfort to participants and avoid negative impacts on their wellbeing. Treat all participants with respect and fairness, avoiding discrimination or bias. Be transparent about any conflicts of interest that could affect the research outcomes. Adhere to relevant laws, regulations, and ethical guidelines governing research involving human participants. Be open about the research methods, findings, and limitations, ensuring accurate and unbiased reporting. These considerations are essential for conducting ethical research that respects the rights and well-being of participants (Singh et al., 2023).

### 3.7 Overview of the agrochemical industry in the study area.

The agrochemical industry in the study area is crucial for supporting agricultural productivity and ensuring food security. It offers a wide range of products and services aimed at enhancing crop yields, controlling pests and diseases, and improving soil fertility. Here are the key aspects of the agrochemical industry: The industry provides various agrochemical products, including fertilizers, pesticides, herbicides, fungicides, insecticides, and plant growth regulators, tailored to address specific agricultural challenges and crop requirements. Both domestic and international players participate in the agrochemical market, fostering competition among manufacturers and distributors to innovate and develop products in response to evolving agricultural needs. Agrochemical products are distributed through agricultural input dealers, retailers, cooperatives, and direct sales from manufacturers, influencing farmers' access to essential inputs. The industry operates within a regulatory framework governed by national and international standards. Regulatory bodies oversee product registration, labeling, safety, and environmental impact assessments to ensure responsible use and safeguard human health and the environment (Roy et al., 2022; Sen et al., 2022). Ongoing technological advancements have led to innovative agrochemical formulations and application methods, integrating precision agriculture technologies like. GPS-guided equipment and remote sensing to optimize input use and minimize environmental impact. Despite contributing to agricultural productivity, the industry faces challenges such as resistance development in pests and weeds, environmental concerns, and public perception issues. However, opportunities exist for sustainable intensification, biobased alternatives, and digital solutions to address these challenges while promoting agricultural sustainability. Research and development initiatives drive continuous innovation in the industry. Collaborations between academia, industry, and government institutions support the discovery of new active ingredients, formulations, and delivery systems to meet farmers' evolving needs and sustainable agriculture goals.

#### 3.8 Analysis of credit access and innovation adoption among agrochemical firms.

Exploring the relationship between credit access and innovation adoption among agrochemical firms sheds light on industry dynamics. Sama et al. (2023) conducted a study revealing a positive correlation between credit availability and firms' innovation endeavors. Conversely, Xuezhou et al. (2022) found that firm size moderates this relationship, with smaller firms facing greater challenges in accessing credit for innovation compared to larger counterparts. Additionally, Nejad et al., (2022) and Sing et al., (2024) emphasized institutional barriers like regulatory hurdles and financial literacy deficits hindering firms' ability to leverage credit for innovation. Despite these insights, understanding the mediating mechanisms and long-term effects of credit access on firms' innovation trajectories remains a research gap. Addressing these gaps will offer a comprehensive understanding of how credit influences innovation in the agrochemical industry (Goswami et al., 2023; Farooq et al., 2022; Sharma et al., 2024). Investigating successful innovations facilitated by Kisan Credit Card (KCC) funding offers valuable insights into agricultural development. Paliwal et al., (2023) examined various instances where KCC funding catalyzed innovative agricultural practices, such as precision farming, drip irrigation systems, and organic farming methods. These initiatives resulted in improved crop productivity, water efficiency, and soil health, while reducing input costs and environmental impacts. Additionally, Datta et al., (2023) showcased the transformative impact of KCC funding on a smallholder farmer's adoption of greenhouse technology, enabling yearround cultivation and enhancing crop yields and income stability. These case studies exemplify the instrumental role of KCC funding in driving agricultural innovation and sustainable development.

### 3.9 Challenges and barriers to innovation in the agrochemical sector.

Exploring the hurdles and impediments hindering innovation in the agrochemical realm unveils a labyrinth of complexities thwarting progress and deterring the embrace of transformative methodologies. In their in-depth analysis, Chaudhari et al., (2024) shed light on regulatory intricacies emerging as a formidable barrier to innovation. They spotlighted the cumbersome approval procedures governing novel agrochemical products, imposing significant roadblocks for companies striving to introduce inventive solutions. These bureaucratic hurdles frequently result in delayed product launches and escalated costs, curtailing firms' inclination to invest in research and development endeavors. Furthermore, the environmental ramifications of agrochemical usage, as underscored by Barrett et al. (2022),

loom large as a formidable impediment to innovation adoption. Heightened awareness of ecological concerns has triggered amplified scrutiny and opposition from an array of stakeholders, including consumers, environmental advocacy groups, and regulatory bodies. The imperative to cultivate environmentally sustainable alternatives compounds the challenges confronting agrochemical enterprises, necessitating a delicate balance between profitability and environmental stewardship. Moreover, Weldon, I. S (2024) pinpointed the enduring prevalence of traditional farming methodologies and farmers' reluctance to embrace change as pivotal barriers to innovation adoption in the agrochemical sector. Despite strides in technology and agronomic methodologies, many farmers remain entrenched in conventional practices, resistant to embracing novel technologies and methodologies. This resistance, stemming from factors such as risk aversion and insufficient awareness, poses a formidable barrier to innovation adoption of innovation, spanning from regulatory complexities and environmental concerns to entrenched farming practices and reluctance to change. Tackling these hurdles demands a concerted collaborative endeavor involving industry stakeholders, policymakers, and research entities to streamline regulatory frameworks, champion sustainable practices, and facilitate technology diffusion and adoption. Overcoming these barriers holds the key to unleashing the sector's innovation potential and fostering sustainable agricultural development.

### **3.10 Interpretation of empirical findings**

The data from our study, analyzed using SPSS, revealed some insightful findings regarding the relationship between the Kisan Credit Scheme (KCC) and innovation adoption in the agrochemical sector. Our analysis showed a strong positive correlation (r = 0.45, p < 0.01) between farmers' utilization of the KCC and their adoption of innovative agrochemical practices. This suggests that farmers who use the KCC are more inclined to adopt new and innovative methods in their farming practices. Furthermore, our regression analysis indicated that KCC utilization is a significant predictor ( $\beta = 0.30$ , p < 0.05) of innovation adoption rate, even when accounting for other variables like farm size and education level. This highlights the crucial role of the KCC in facilitating the adoption of innovative practices in agriculture. These findings underscore the importance of the KCC in driving agrochemical innovation among farmers. It suggests that enhancing the accessibility and effectiveness of the KCC could further promote innovation adoption in the agrochemical sector, ultimately leading to more sustainable and productive agricultural practices (Kaur et al., 2022).

#### 3.11 Comparison with existing literature and theoretical frameworks

Existing literature suggests that the relationship between R&D expenditure, innovation adoption, and firm performance in the agrochemical sector is consistent with theoretical frameworks such as the resource-based view (RBV) and innovation diffusion theory (IDT). Studies by Joshi et al., (2022) and Agarwal, S (2023) support the notion that higher R&D investment leads to greater innovation adoption, which aligns with the RBV perspective. According to RBV, firms that invest in valuable, rare, and non-substitutable resources, such as R&D capabilities, are more likely to achieve sustained competitive advantage and superior performance. Similarly, the positive correlation observed between R&D expenditure and the number of new products introduced in our study corroborates findings from the RBV literature, emphasizing the strategic importance of investing in innovation-related resources for agrochemical firms.

#### 3.12 Implications for policy and practice.

The implications of our study's findings for policy and practice in the agrochemical sector are profound. As highlighted by Kannaujiya et al.,(2023), facilitating access to credit is paramount for fostering innovation adoption among agrochemical firms. Therefore, policymakers should consider implementing measures such as streamlined loan approval processes and financial incentives to encourage investment in research and development (R&D) initiatives. Additionally, regulatory frameworks need to strike a balance between promoting innovation and ensuring environmental sustainability and consumer safety, as noted by Baur, P (2022). Practitioners within the industry can leverage these findings to prioritize R&D investments and foster a culture of innovation within their organizations. Collaborative initiatives between industry stakeholders, research institutions, and government agencies are also crucial for driving innovation and sustainability, as emphasized by Beck, S et al., (2022). By aligning policy interventions with industry needs and fostering collaboration, policymakers and practitioners can create an enabling environment that stimulates innovation, enhances competitiveness, and contributes to long-term agricultural sustainability.

### 3.13 Suggestions for promoting innovation and entrepreneurship in the agrochemical industry through KCC

To foster innovation and entrepreneurship in the agrochemical industry through Kisan Credit Card (KCC) initiatives, policymakers and stakeholders should focus on several key strategies. Firstly, as advocated by Mathurkar, P. V. (2023), and Bhalerao et al., (2022)there's a need to enhance accessibility to KCC funding for agrochemical firms, particularly small and medium enterprises (SMEs), by streamlining application processes and providing tailored financial products. On a positive note, aligning with government initiatives like KCC offers an opportunity for the agrochemical industry to promote sustainable practices and innovation in agriculture (Onoda et al., 2022). Additionally, collaborating with private

sector entities can provide access to new markets, technologies, and resources, facilitating the development and adoption of innovative agrochemical solutions (Pandey, N et al., 2022). Looking ahead, the industry can capitalize on increasing demand for sustainable agrochemicals and advancements in precision agriculture technology to drive future growth (Orzel, E. C, 2024). Overall, these findings suggest that addressing challenges related to awareness, education, regulatory hurdles, and fostering collaboration with the private sector and government initiatives is crucial to unlocking the full potential of the KCC for promoting agrochemical innovation and sustainability.

Additionally, Kohl, R (2022) highlight the importance of offering specialized training and capacity-building programs to equip agrochemical entrepreneurs with the necessary skills and knowledge to innovate effectively. Moreover, Annosi, M. C et al., (2022) emphasize the significance of creating a supportive ecosystem that fosters collaboration between agrochemical firms, research institutions, and government bodies to facilitate technology transfer and knowledge exchange. By implementing these recommendations, policymakers and stakeholders can leverage KCC initiatives as a catalyst for promoting innovation, entrepreneurship, and sustainable growth in the agrochemical industry, ultimately contributing to agricultural development and economic prosperity. In conclusion, the implementation of the Kisan Credit Scheme (KCC) for agrochemical innovation faces challenges related to awareness, regulatory hurdles, and education. However, there are promising opportunities for growth through integration with government initiatives and collaboration with the private sector. Addressing these challenges and leveraging these opportunities can significantly benefit the agrochemical industry by promoting sustainable practices and fostering innovation. By improving awareness among farmers, streamlining regulations, and fostering partnerships, the KCC can play a crucial role in driving agrochemical innovation and sustainability in agriculture (Paliwal et al., 2023).

### 4. Summary of key findings

The literature review and analysis underscore several critical insights into implementing the Kisan Credit Scheme (KCC) for agrochemical innovation. It reveals that farmers' limited awareness about KCC benefits and procedures is a major hurdle, emphasizing the need for targeted education efforts (kumar, A. 2024). Moreover, the complex bureaucratic procedures and stringent eligibility criteria pose challenges in accessing KCC credit for agrochemical innovation, highlighting the urgency for streamlined processes and farmer-friendly policies (Abraham, M., & Pingali, P 2022).

The conclusion of the data analysis suggests that the predictor variables, namely AGE and EDU, do not significantly predict the dependent variables, Awareness and KCC utilization, respectively. The regression analyses revealed weak relationships between the predictor and dependent variables, with low R-square values indicating that AGE and EDU alone do not explain much of the variability in Awareness and KCC utilization. For Awareness, the regression model including AGE as a predictor was not statistically significant, as evidenced by the non-significant F-value and p-value. Similarly, for KCC utilization, the regression model including EDU as a predictor also failed to reach statistical significance. These findings imply that factors other than AGE and EDU may play a more substantial role in influencing Awareness and KCC utilization among agricultural borrowers. Further research exploring additional variables and potential interactions among variables may provide a more comprehensive understanding of the determinants of Awareness and KCC utilization. While the current analysis did not yield significant results, it highlights the complexity of factors influencing Awareness and KCC utilization in the context of agricultural finance. Future studies employing more robust methodologies and considering a broader range of variables are warranted to deepen our understanding of these phenomena and inform targeted interventions to promote financial literacy and credit access among agricultural borrowers.

#### 4.1 Limitations of the study and avenues for future research:

While our study sheds light on the role of the Kisan Credit Scheme (KCC) in facilitating entrepreneurship and sustainability within the agrochemical industry, it is important to acknowledge several limitations and suggest avenues for future research (Jacquet et al., 2022). Firstly, our research focused primarily on quantitative analysis, overlooking the qualitative aspects such as stakeholder perspectives and contextual nuances. Future studies could employ mixed-methods approaches to capture a more comprehensive understanding of the complex dynamics involved. Secondly, our study was limited to a specific geographical context, potentially constraining the generalizability of findings to other regions or agricultural sectors (Dalal, A, 2024). Future research could explore how the implementation and effectiveness of KCC vary across diverse socio-economic and agro-climatic settings, thus enhancing the external validity of findings. Moreover, our study primarily examined the direct effects of KCC on entrepreneurship and sustainability, neglecting potential mediating and moderating factors such as financial literacy, institutional support, and market structures (Bindra, S et al., 2023). Future research could investigate the underlying mechanisms through which KCC influences entrepreneurial behavior and sustainable agricultural practices, thus providing actionable insights for policymakers and practitioners. Additionally, while our study focused on the agrochemical industry, future research could explore the applicability and effectiveness of KCC in other agricultural sub-sectors such as organic farming, horticulture, or livestock production (Beevi, C. A et al., 2023). Comparing the impact of KCC across different agricultural domains could offer valuable insights into its broader implications for rural development and food security. This study did not consider long-

term sustainability aspects such as environmental conservation, social equity, and resilience to climate change (). Future research could adopt a more holistic approach to assess the holistic impacts of KCC on agricultural systems, thus informing more integrated and sustainable development strategies. In summary, while our study contributes to understanding the role of KCC in promoting entrepreneurship and sustainability in the agrochemical industry, addressing these limitations and exploring avenues for future research will enrich our understanding and inform more effective policy and practice interventions.

#### 5. Conclusions

In conclusion, this exploration paints a vivid picture of the Kisan Credit Scheme (KCC) as more than a financial tool. It highlights the KCC's role as a transformative force in the agricultural landscape, nurturing the dreams and aspirations of farmers while promoting sustainable agrochemical practices. By providing accessible credit, the KCC empowers farmers to innovate and explore new frontiers in agrochemical formulations, fertilizers, and pesticides with confidence. This study emphasizes the personal journeys of individual farmers, showcasing how the KCC acts as a companion that guides them through the complexities of modern agriculture. The KCC's influence extends beyond mere financial support, instilling a sense of environmental responsibility among farmers. It encourages them to make agrochemical choices that harmonize with ecological rhythms, fostering a sustainable approach to farming. Through personal anecdotes, the study reveals how market linkages facilitated by the KCC create valuable connections between farmers and markets that value not just the produce but also the principles of responsible farming. Moreover, the KCC's risk mitigation features provide farmers with the security to dream beyond their immediate challenges. This security allows them to invest in sustainable practices and contribute to a future where agriculture and environmental stewardship coexist harmoniously. Ultimately, the Kisan Credit Scheme is depicted as a crucial enabler of sustainable growth, offering farmers the financial stability and moral support needed to navigate the evolving agricultural landscape and champion the cause of environmental sustainability.

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