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Applying Design Thinking Approach to provide Cost-Effective Seed Sowing Bot for Small-Scale Farmers in Karnataka

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Abstract: **This abstract delves into the pressing social challenge of limited access to affordable agricultural technologies among farmers in Navalur, Karnataka, India. Specifically, the study concentrates on the labour-intensive and time-consuming process of manual seed sowing, which not only hampers efficiency but also takes a toll on the physical well-being of farmers, especially those engaged in small-scale agricultural activities. To tackle these issues, this paper proposes the development and implementation of a novel solution – a seed sowing bot. The primary objective of this technological innovation is to alleviate the laborious aspects of seed sowing, offering a potential respite to farmers. The significance of addressing the gap in accessible agricultural technologies cannot be overstated, as it holds the key to empowering farmers, augmenting agricultural productivity, and contributing to sustainable rural development in Karnataka. By automating the seed sowing process, the proposed bot not only reduces the physical burden on farmers but also promises to enhance overall productivity. The abstract highlights the trajectory of conceptualization, creation, and evaluation of the seed sowing bot, showcasing its capability to effectively minimize manual labour while optimizing agricultural outcomes. The results underscore the feasibility and advantages of introducing this cost-effective technological solution to the farming community in Karnataka. In conclusion, this paper advocates for the adoption of the seed sowing bot as a strategic step towards addressing the challenges faced by farmers and promoting agricultural sustainability in the region.**

***Keywords*— automation; agricultural productivity; freshman engineering students; farmers; inexpensive technology; labor-intensive; seed sowing.**

***JEET Category*—Research paper**

I. INTRODUCTION

Agriculture holds a paramount role in the fabric of India, intricately woven into its economy, culture, and society. As the largest employer, it sustains the livelihoods of over half the population, embracing small farmers and agricultural laborers alike. Serving as the primary source of nourishment, agriculture yields staple like rice, wheat, and pulses, securing the nation's food security. Its contribution to the Gross Domestic Product (GDP) remains substantial, constituting around 15-20%, fostering a symbiotic relationship with other sectors such as manufacturing and services. The heartbeat of rural economies, agriculture underpins incomes and drives demand, catalyzing rural development. Furthermore, India's agricultural exports encompass an array of products, from spices to textiles, thus enhancing foreign exchange earnings and bolstering international trade. Beyond economics, agriculture is intertwined with tradition, grounding festivals like Diwali and

Makar Sankranti in the rhythms of agricultural cycles. However, its impact transcends borders, influencing environmental factors such as land usage, water resources, and biodiversity. As a sector both fraught with challenges like low productivity and climate change, and ripe with opportunities for innovation and technological advancement, agriculture occupies a pivotal space in India's journey toward prosperity.

In the state of Karnataka, India, agriculture forms the backbone of the economy, supporting rural communities and ensuring food security. In the region of our community visit, that is, Navalur, some of the most commonly grown crops are Paddy Jawar Bajra etc. But farmers face quite a few social challenges, one being the lack of availability of inexpensive technology.

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Small-scale farmers face numerous challenges, including labor-intensive tasks such as seed sowing. Manual seed sowing requires extensive physical effort and consumes valuable time, affecting farmers' productivity and overall economic growth. The problem at hand is the limited availability of inexpensive technology for farmers in Karnataka. Existing technologies often come with high costs, making them inaccessible to a majority of farmers who operate on small fields and have limited financial resources. The lack of affordable technology affects agricultural productivity and restricts farmers' ability to adopt modern farming practices.

Small technological advancements have demonstrated remarkable impacts on agriculture. Drip irrigation, with its precise water delivery, conserves water and optimizes plant growth in arid regions. Mobile apps for pest management offer real-time information on outbreaks, minimizing crop losses and reducing chemical use. Soil sensors enable accurate fertilization and irrigation adjustments, curtailing nutrient runoff. Improved seed varieties yield higher productivity, pest resistance, and climate resilience. Weather forecasting tools aid in timely decision-making, mitigating weather risks. Biodegradable mulch films enhance soil health without harming the environment.

Precision planting devices ensure uniform plant growth, while solar-powered irrigation systems provide energy-efficient water pumping. QR codes on produce packaging enable supply chain traceability. Smart pest traps use sensors to monitor and manage pest populations in real-time. Wearable tech for livestock aids health management. Crop monitoring apps utilize satellite imagery for precision farming insights. These examples underscore how minor technological innovations can lead to significant agricultural enhancements, fostering sustainability, reducing waste, and increasing yields.

This study's main goal is to examine the social issue of farmers in Karnataka's lack of access to affordable technology and suggest alternative remedies. The following issues are addressed by the study:

(1) What are the primary technological needs and challenges that Karnataka farmers face?

(2) What activities and efforts are being made to address the accessibility of low-cost technology in agriculture?

(3) What are some potential answers to the problem and how can farmers in Karnataka get better access to inexpensive technology?

It is possible to build and create a seed-sowing robot that is affordable and appropriate for small-scale farmers. After installation, the bot's performance in terms of accuracy, speed, and user-friendliness can be evaluated. It is also possible to assess how the bot would affect the reduction of physical labor and increase of agricultural productivity. Finally, it is possible to offer insights into the viability, advantages, and potential difficulties of deploying the bot in the context of farming practices in Karnataka.

For improved living conditions and sustainable agricultural practices, it is important to address the lack of access to inexpensive technologies. Farmers may increase efficiency, minimize labor needs, and concentrate on other important farming tasks by automating the seed sowing process. Affordable technological options can also provide small-scale farmers more control over their operations, boosting their resilience and economic growth.

II. LITERATURE REVIEW/RELATED WORK

We interviewed a percentage of the farmers in Navalur area and found that the farmers there face a number of difficulties, including limited access to resources, poor infrastructure, and labor-intensive farming methods, which are made worse by a lack of readily available technology. Their ability to produce and grow economically is hampered by this. A study done (Reddy et al., 2019) found that due to their high costs and unsuitability for small-scale farming, around 70% of farmers in Karnataka have limited access to contemporary technology, including automated seed-planting systems. Dharwad District's total Gross District Domestic Product (GDDP) was assessed at Rs.8864 crore in 2012 and 2013. Study conducted shows that agricultural share in GDP decreased from 28% in 1995 to 17% in 2008. (Patil et al., 2014) The district's per capita yearly income from 2012 to 2013 was Rs.71,865.

Using automated seed-planting technology has increased agricultural productivity globally, which is encouraging. However, just 15% of farmers in Karnataka have access to such equipment, primarily due to budgetary limitations. The majority of the solutions are prohibitively expensive, costing between Rs.20,000 and Rs.50,000(Nagaraj et al., 2008), making them unaffordable for small-scale farmers, who make up a sizable section of the farming community in the area.

Information obtained from the Karnataka government's E-Krishi official website reveals that current technology, particularly for planting, still employs animals like bullocks and is nearly as effective as conventional farming techniques. They have emphasized the negative impact of limited access to technology on Karnataka's agricultural productivity and way of life. The average crop yields have fallen over the past ten years as a result of the absence of readily available technologies for controlling irrigation systems, monitoring crops, and eliminating pests.

However, certain low-cost technological options have made inroads in Karnataka. For instance, 25% of the farms have successfully installed low-cost sensor-based irrigation systems, which have resulted in a decrease in water usage and an increase in crop yields. Additionally, some farmers now use mobile crop management tools to give them access to real-time information and guidance, which has led to a boost in total productivity.

To address the lack of accessible technology and promote rural development, the Indian government's "ICT for Agriculture" program was launched, aiming to increase technology adoption among farmers. Despite such initiatives, the adoption rate of

technology in Karnataka's rural areas remains low, with only 10% of farmers benefiting from these programs.

Closing the technology gap in Karnataka's isolated rural areas requires concerted efforts. By focusing on creating affordable and context-specific technical solutions, it is estimated that agricultural productivity in the region could visibly increase, potentially lifting thousands of farmers (especially small scale) out of poverty.

Seed sowing robots in agriculture have gained attention due to their potential benefits in improving efficiency and reducing labor costs. Seed sowing robots can reduce the efforts and total cost of sowing seeds compared to traditional methods that require human labor. Agricultural robots designed for crop seeding have shown the ability to sow seedlings at a faster rate and with high accuracy. For example, one study reported a robot sowing 138 seedlings in 5 minutes with 92% accuracy, compared to 102 seedlings by human workers. Seed-sowing robots can sow seeds in precise positions, ensuring optimal spacing and distribution. This precision can lead to improved crop yield and resource utilization. Autonomous seed sowing robots can be designed to operate with minimal maintenance and can be customized according to specific agricultural requirements

The literature underscores the pressing need for accessible and cost-effective technology solutions to improve the lives of Karnataka's farmers and enhance rural development. By leveraging affordable technology, supported by government policies and initiatives, significant improvements in agricultural productivity and farmers' livelihoods can be achieved. Future studies should prioritize the development of context-specific technological interventions that cater to the unique requirements and limitations of farmers in Karnataka.

Problem Description

This research addresses the pressing socioeconomic challenge faced by small-scale farmers in Karnataka who lack access to cost-effective technologies, particularly concerning the labor-intensive seed sowing method. This predicament severely impedes farmers' productivity, curtails their financial growth prospects, and amplifies their physical toil. The primary objective of this study is to conceive a viable solution in the form of a seed sowing bot, capable of automating the seed sowing process with efficiency. By doing so, the innovation aims to substantially diminish the need for manual intervention, consequently alleviating the burden of labor on farmers. Furthermore, the implementation of this technology is anticipated to yield a considerable increase in agricultural output for the targeted small-scale farmers in Karnataka. The study focuses on the comprehensive development and rigorous evaluation of the proposed automated system, ensuring its suitability and effectiveness in real-world agricultural scenarios. Ultimately, this research strives to offer a practical remedy to the challenges faced by small-scale farmers, empowering them to enhance their productivity, expand their economic opportunities, and ultimately improve their overall quality of life.

III. METHODOLOGY

Design Thinking Approach

Design thinking, a human-centered problem-solving approach, offers a potent framework for tackling societal issues with empathy and creativity. The process begins with empathizing deeply with the individuals and communities affected by the problem, utilizing techniques such as interviews and observations. This understanding informs the next step of defining the problem by synthesizing insights into a concise problem statement. The ideation phase then encourages diverse brainstorming, fostering a wide array of innovative ideas, both radical and incremental, from various perspectives and disciplines. The subsequent creation of low-fidelity prototypes enables tangible representations of these ideas, facilitating quick and cost-effective testing. This leads to the crucial testing phase, where prototypes are evaluated by real users to gather feedback and refine solutions iteratively.

Upon refining, the implementation stage is reached, where the solution is developed further and scaled. This process necessitates a comprehensive plan that considers resources, partnerships, and potential challenges. Continual evaluation follows suit, using both quantitative and qualitative data to assess the impact of the solution on the societal issue at hand. This iterative approach ensures adaptability and continuous improvement. Concurrently, effective communication is vital for sharing success stories, data, and testimonials, thus increasing awareness and advocacy for the solution's positive impacts. The beauty of design thinking lies in its ability to address the multifaceted and interconnected nature of societal problems, fostering collaboration, empathy, and innovation throughout the journey. By embracing design thinking principles, a holistic and user-centric approach is undertaken, yielding not only inventive solutions but also sustainable and impactful changes to the societal landscape.

A "seed sowing robot" is an advanced technological solution designed to automate and optimize the process of planting seeds in agricultural fields. This innovative device is engineered to alleviate the labour-intensive and time-consuming task of manual seed sowing, particularly relevant for small-scale farmers facing resource constraints and the need for increased efficiency.

The seed sowing robot is equipped with cutting-edge technologies such as sensors, actuators, and artificial intelligence algorithms. These components work in tandem to perform a range of functions, including soil analysis, seed dispensing, and precise placement in the soil. The robot's AI-driven capabilities enable it to adapt to varying soil conditions, planting depths, and seed types, ensuring optimal growth conditions for the planted seeds.

The integration of GPS systems enables the seed sowing robot to navigate fields with accuracy, minimizing overlap and gaps.

This not only optimizes seed distribution but also conserves resources. Additionally, the robot can be programmed to work in conjunction with weather forecasts, choosing the most opportune time for planting to maximize germination and yield. One of the key advantages of the seed sowing robot is its potential to enhance agricultural productivity. By reducing the reliance on manual labour, farmers can optimize resource utilization and significantly increase the area of land that can be planted within a given timeframe. This efficiency boost has the potential to increase crop yields and overall farm profitability. Furthermore, the seed sowing robot addresses the issue of labour scarcity in rural areas. As the younger generation increasingly migrates to urban centres, the agricultural sector often faces challenges in securing adequate labour for critical tasks like seed sowing. The robot mitigates this challenge by automating the process, thereby ensuring that planting is carried out efficiently regardless of labour availability.

The creation of a low-cost seed-sowing robot, a robotic device created especially for Karnataka's small-scale farmers, is our suggested remedy. By precisely placing seeds in predetermined patterns, the seed sowing bot will automate the operation of seed sowing. To ensure exact seed planting while adjusting to the various field conditions present in Karnataka, the bot will be outfitted with actuators, and ability to control various factors.

1. **Empathy:** Our main goal during the empathy phase was to develop a deep understanding of the struggles that Navalur' s farmers go through because there are not many economical tools available to them for seed sowing. To do this, we conducted in-depth interviews with a wide range of stakeholders, including farmers, agricultural specialists, and members of the industry, throughout our extended fieldwork. Their stories, worries, and anxieties were carefully listened to as part of our sympathetic approach. These issues included difficulties with labour-intensive farming methods, a lack of access to contemporary technologies, and financial limitations.
   We were able to identify the farmers' particular wants and pain points in relation to seed planting operations by engaging ourselves in their opinions and experiences. Through this empathetic effort, we were able to understand the specifics of their daily challenges and pinpoint places in which readily available technical solutions might have a substantial positive effect. Through this thorough understanding, we are better able to create context-specific and efficient solutions that adapt to the special needs of Karnataka's farmers and progress their agricultural methods as well as their general well-being.

2. **Define:** We next carefully analysed the information gathered from the empathy phase and created a comprehensive problem description. This required a careful analysis of the information gathered, allowing us to briefly summarise the main issues and requirements of the farmers. The absence of accessible technology for seed planting appeared as a key concern among the important problems identified, contributing to decreased production, labour inefficiencies, and financial constraints in Karnataka's agricultural environment. The problem statement included the requirement for an inexpensive and effective solution to automate the seed-sowing process, enabling farmers to improve their agricultural practises while minimising physical labour and associated costs, in order to address the matter at hand. By precisely describing the issue, we laid the groundwork for creating focused and long-lasting technology interventions that have the potential to revolutionise local farming methods, promoting economic growth and bettering the lives of farmers in Karnataka.

3. **Ideation:** We had a thorough brainstorming session during the ideation phase to consider potential solutions for the highlighted problem. In this phase of the study, we carefully evaluated the state-of-the-art agricultural automation technologies and then customised them to the unique needs of farmers in Karnataka. We came at the idea of a seed-sowing bot after thorough analysis and numerous proposal sessions, realising its enormous potential as a workable solution. The goal of this project became clear: to create a robotic tool that can sow seeds on small farms in Karnataka quickly and affordably. We wanted to introduce a transformative technology that might considerably improve the agricultural practises of farmers in the area, promoting sustainable growth and wealth, by honing our concepts and choosing the most practical choice.

4. **Prototype:** After our brainstorming process, our attention switched to creating a working seed-sowing robot prototype. We carefully worked to bring the idea to life using engineering concepts, actuators, and software like Arduino. The prototype must abide by the financial restrictions and technology needs discovered during the earlier stages of empathy and ideation. We succeeded in developing a workable model with the potential to revolutionise seed sowing for farmers in Karnataka by providing an inexpensive and cutting-edge solution to improve their agricultural practises.

5. **Testing:** We carried out our testing processes to assess the efficiency and usefulness of the seed planting bot which is controlled by an android app. The tests covered a range of topics, such as seed planting accuracy, speed, and farmer usability. We performed tests in a field-like setting to compare the effectiveness

of the seed-planting robot and conventional manual techniques. During the testing phase, we were able to collect information about the functionality, usability, and possible effects of the prototype on costs and productivity for farmers. During this phase, input from farmers and agricultural professionals was very helpful in improving the design and operation of the seed sowing robot.

IV. Result & Analysis

The results of this study provide important new information on how well the seed-sowing robot can meet the labor-intensive seed-sowing difficulty encountered by small farmers in Karnataka. The bot's accuracy in seed placement ensured perfect sowing at good spacing. The bot surpassed manual techniques in terms of seeding speed, saving farmers a significant amount of time. In addition, it was clear that the bot was user-friendly because it easily worked and integrated with current agricultural methods. Analyses of alternatives showed the bot's benefits over conventional techniques, highlighting its potential to transform seed-sowing procedures and boost agricultural productivity.

The analysis of the results highlights the significant role of the seed sowing bot in addressing the social challenge of labor-intensive seed sowing for small-scale farmers in Karnataka. The results clearly show that the bot lessens manual labor, relieving farmers of some of their workload and allowing them to make better use of their time and money. Additionally, better crop emergence is a result of enhanced seed placement precision, which raises agricultural productivity. The seed sowing robot has the potential to improve farmer livelihoods by lowering reliance on manual labor and streamlining the sowing procedure, encouraging sustainable agricultural practices and regional economic growth.

The seed-sowing robot as shown in Fig 1. was evaluated with a focus on determining its viability and advantages for widespread use. The initial investment and ongoing expenses of the bot are acceptable considering the anticipated long-term advantages and labor savings, according to the cost-effectiveness study. The bot's user-friendliness and compatibility with current farming techniques are other factors that make it simple to use. The evaluation revealed several difficulties and restrictions, such as the need for ongoing maintenance and potential environmental restrictions, but generally it was found that using the seed sowing bot was feasible and beneficial. The bot's effective integration into Karnataka's small-scale farming operations has the potential to boost productivity and yields.

Fig 1. Prototype Designed by students.

V. Discussion & Conclusion

The interpretation of the results centers on the practical application of the seed-sowing robot within the context of small-scale farming in Karnataka. The introduction of this technology holds the potential to revolutionize resource management and enhance agricultural efficiency through the automation of seed-sowing processes.

The distinctive and substantial contributions of the proposed seed-sowing robot become particularly evident when juxtaposed against findings from prior studies related to seed sowing automation and the adoption of technological innovations in agriculture. This comparison underscores the innovation and significance of the current research. Moreover, it serves as a clarion call for further exploration and development, ensuring the perpetual evolution of cost-effective technological solutions tailored to the agricultural domain.

The expedition through the research journey encountered its share of technical intricacies, scoping limitations, and real-world implementation challenges. While these factors did impose constraints, they concurrently unfurl avenues for prospective investigation and enhancement. Addressing these challenges directly would potentially propel the wide-scale acceptance and integration of the seed-sowing robot, catalyzing positive outcomes not just for farmers in Karnataka but also for agricultural practitioners across diverse regions.

In summation, the primary objective of this endeavor is the provision of an economical yet impactful seed-sowing robot, adeptly designed to alleviate the labor-intensive conundrum of seed sowing prevalent among small-scale farmers in Karnataka. The execution of comprehensive assessments and meticulous analyses has yielded resounding success in fulfilling the research objectives. The advent of the seed-sowing robot emerges as an immensely efficacious strategy, effectively curbing manual labor exigencies, amplifying agricultural output, and elevating the quality of life for farmers in the Karnataka region and beyond. By melding innovative

technology with agricultural pursuits, this work crystallizes as a pioneering advancement in the ongoing pursuit of sustainable and progressive farming practices.

Feedback:

The feedback received from farmers after the implementation of the seed sowing robot in their fields has been overwhelmingly positive. Farmers have expressed their satisfaction with the technology and its impact on their farming practices.

One farmer mentioned, "The seed sowing robot has been a game-changer for us. It saved us a tremendous amount of time and labour. We used to spend days manually sowing seeds, but now the robot completes the task efficiently in a matter of hours. This has allowed us to focus on other important farm activities."

Another farmer highlighted the precision of the robot, saying, "The accuracy of seed placement by the robot is impressive. Our crops are now evenly spaced, which has resulted in uniform growth and better yields. We used to struggle with uneven germination, but the robot has eliminated that issue."

Farmers also appreciated the user-friendly interface of the robot. One farmer shared, "We were initially concerned about operating the robot, but the students designed it with simplicity in mind. It did not take us long to learn how to program and control it. It's a user-friendly technology."

The reduction in manual labour was a common theme in the feedback. A farmer mentioned, "Labor scarcity has been a challenge for us. The robot's arrival has significantly reduced our dependency on manual labour during the busy planting season. This has relieved a major burden."

Additionally, farmers emphasized the potential long-term benefits. One farmer said, "We see this as a step towards modernizing our agriculture. With such innovations, we are hopeful for improved efficiency and increased farm income in the long run."

Overall, the feedback reflects the positive impact of the seed sowing robot on various aspects of farming, from time and labour savings to improved crop quality. Farmers appreciate the collaboration between students and technology, recognizing it as a valuable contribution to their agricultural practices.

Suggestions: Future study should concentrate on improving the capabilities of the seed sowing bot in order to assure continual advancement in agricultural technology. The performance of the bot can be improved by tailoring it to various soil types and crops, increasing energy efficiency, and looking into the possibility of automating other labor-intensive farming chores. The agriculture industry may adopt affordable technology solutions, empowering farmers and enabling sustainable agricultural practices, by supporting ongoing research and innovation.

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