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MULTIFUNCTION AGRICULTURAL ELECTRIC VEHICLE

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Abstract: The agricultural industry in making a paradigmatic transition towards sustainability and efficiency due to the imperative need to solve environmental problems and food security issues. Agriculture based multifunction E-vehicle have surfaced as an innovative solution, combining advanced electric vehicle technology with general purpose agricultural uses. This abstract gives an idea of the kay aspects and implication of such vehicle are electricity powered, lowering greenhouse gas emissions and dependency on fossil fuels, which makes them a green-friendly option. The incorporation of E-Vehicles in agriculture holds the promise of lower operating costs, greater productivity, and a reduced carbon footprint. The E-Vehicle for Agriculture Remote Operated In order to prevent different problems which impact agricultural fields, agricultural electrical vehicle is required, to achieve the goals such as weed detection, irrigation, crop protection and Bug Spray. This is the design features of electric vehicle which is environmentally friendly in nature and automated. The different technologies employed are sensor technology. The developed EV not only employs battery power but also employs renewable Energy to carry out all its functions. The model proposed is economical and dependable, also applicable for linear agricultural purposes. The electrical vehicle has a significant contribution towards precision farming, which is enhancing the efficiency of crop production without affecting the various agriculture variables and lowering the costs of production. The planned EV model aims to fulfill agricultural needs like protection of crops, watering, bug spray (i.e. pesticide spraying) with obstacle detection feature. The model is self- powered for soil moisture checking to initiate watering of the field or Motor off function. The delta robot used to pick the weed from the field has a ground level clearance of 10 cm does the job.

Keywords: Agriculture vehicle, Seed sowing machine, Sprayer, Photo voltaic cell, Electrical vehicle (EV).

I. INTRODUCTION

India is primarily an agricultural country, with around 70% of its population depending on farming for their livelihood. The roots of Indian agriculture trace back to ancient texts like the Rigveda. While India stands as the second-largest agricultural producer globally, the sector still faces numerous challenges. Despite its vast workforce, agriculture in India lags behind other nations in terms of efficiency and productivity.Key issues include limited farm mechanization, fragmented land holdings, poor financial conditions of farmers, and unorganized farming practices. Due to these challenges, many farmers cannot afford advanced machinery, which hampers productivity. Traditional farming tools require intense manual labor and multiple repeated efforts, leading to increased time and reduced efficiency.

To address these concerns, agricultural mechanization becomes crucial. A multifunctional farming vehicle could solve several of these issues by integrating tasks such as seed sowing, fertilizer spraying, tilling, and digging into one system. Targeting small-scale farms, this vehicle aims to be cost-effective and efficient. It can function continuously in all seasons and weather conditions, offering a sustainable alternative through the use of solar energy. The vehicle's primary components include a solar panel, rechargeable battery, DC motor, and centrifugal pump. The solar panel charges the battery, which then powers the motor and other essential parts. The motor converts electrical energy into mechanical energy, enabling operations like sowing, watering, and ploughing via a controlled switch system. Power is transmitted using gear mechanisms such as spur gears, worm gears, and chain-sprocket systems. This design is especially beneficial for small farms, combining multiple agricultural functions into a single compact, eco-friendly machine.

II. LITERATURE SURVEY

Aniruddha Autade and his team [1] highlighted the advantages of implementing a multi-functional agricultural vehicle, especially for small-scale farms. Their work outlines how such a machine can integrate various agricultural tasks,

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including crop cutting, land leveling, and ploughing. The study emphasizes the importance of a compact and efficient design that can reduce labor requirements. This system enables the vehicle to perform multiple tasks by targeting specific rows and columns at consistent intervals, tailored to the type of crop being cultivated, thus enhancing productivity with minimal human effort.

Dr. C.N. Sakhale et al., *Review Paper on "Multipurpose Farm Machine" * [2021]: This paper [2] discusses the mechanization of agricultural machines, particularly focusing on the ploughing tool. The research highlights how replacing the ploughing teeth can extend the life of the tool, offering valuable insights for improving machine durability.

Dhatchana moorthy N. et al., *Design and Fabrication of Multipurpose Agriculture Vehicle* [2021]: This research [3] emphasizes the design of the machine's chassis and frame, using lightweight materials to reduce costs. The vehicle is designed to perform various tasks, with the capability to work within specific rows and columns at predefined intervals, catering to different crop needs.

Francesco Mocera et al. [4] explored a multibody (MTB) model of a compact tracked vehicle designed for agricultural use. These vehicles are expected to function under a wide range of operating conditions, often while using various attachments. Given that they operate on unpredictable and uneven terrain, such as sloped or rough fields, the tractive force can vary significantly. This variability frequently necessitates numerous field tests to assess the machine's performance. To address this, a virtual model was developed using Creo software, allowing simulation of different working scenarios by incorporating the vehicle's dynamic characteristics. The research primarily examines the overall kinematic behavior of the vehicle, comparing predefined motion inputs with the actual resulting movements Das and Patel [5] focused on solar-powered agricultural tools, highlighting their utility in rural and off-grid regions. Their study confirmed that solar power can meet the energy demands of low-load agricultural tasks, although performance under variable weather conditions remains a concern. Li et al. investigated precision farming technologies by integrating GPS and sensor systems into farm vehicles, which led to improved operational accuracy and optimized resource usage.

Aditya Sharma and Dr. Puja Tripathi proposed a paper [6] (August 2021) multipurpose agricultural robots are researched and developed mainly for harvesting, fertilizer spraying, picking fruits, sowing, and monitoring crops. Robots like these are brilliant replacements for manpower to a far better extent as they deploy unmanned sensors and machinery systems.

Khondoker Abdul Mottaleb et al. [7] carried out a comprehensive review emphasizing the importance of introducing agricultural machinery that is well-suited to the needs of smallholder farmers in South Asia. The study argues that "scale-appropriate" technologies have the potential to significantly improve both land productivity and labor efficiency. Despite these benefits, the high cost of acquiring such equipment often makes ownership unrealistic for small-scale farmers. To overcome this barrier, rental and shared service markets have developed for key operations such as soil preparation, irrigation, and post-harvest processing. These services enable farmers to access modern machinery on a pay-per-use basis, which reduces the burden of capital investment. The paper also notes that, although these rental models have become more prevalent, there remains considerable opportunity to expand their availability and efficiency. For effective scaling, the authors suggest that a better understanding of the economic and institutional factors influencing machinery adoption is necessary. This includes examining farmer preferences, access to credit, local service infrastructure, and government policy support. Additionally, the study explores various challenges faced in the dissemination of small-scale equipment and highlights the role of public-private partnerships in promoting wider adoption of mechanization among resource-constrained farming communities.

Mohamed N Faoui et al [8] have studied and improved energy extraction efficiency of solar panel. It projects the idea that the efficiency depends on the inclination angle of the solar panel. So, this inspired the idea to maintain our solar panel angle between 30 degrees to 45 degrees. The effect of this inclination angle is that we obtain improved energy transmission to the vehicle.

Pratik Kumar V. Patel and Mukesh Ahuja, *Research and Design of Multipurpose Agriculture Equipment* [2021]: This research [9] paper explores how traditional agricultural machinery can be transformed into modern, efficient tools. By integrating key findings, the team developed a fertilizer distributor that optimizes fertilizer application across fields. The combination with a seed hopper ensures a streamlined and efficient process.

Nitin Kumar Mishra et al. [10] emphasized that addressing the country's growing energy demand is a critical challenge faced by engineers, social scientists, entrepreneurs, and industrialists alike. With rising concerns over the sustainability

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of conventional energy sources, the paper advocates for the adoption of non-conventional energy systems as a practical alternative. Among various sectors, agriculture stands out as a major area where renewable energy—particularly solar power—can be effectively implemented. The use of solar energy for agricultural operations, such as water pumping for irrigation in rural and remote areas lacking electricity, offers a reliable and environmentally friendly solution. The study also explores the integration of mechanized tools that act as a bridge between energy sources and farm operations. Solar-powered devices not only reduce dependence on fossil fuels but also lower operational costs, making them economically viable for small and marginal farmers. The authors propose that such systems be designed to be user-friendly, low-maintenance, and fuel-independent, which further enhances their value in rural farming communities. Overall, the paper presents solar energy as a sustainable and cost-effective option that can significantly benefit the agricultural sector while addressing broader energy concerns.

Dr. Smita Joshi, Vinit Joshi and Shah Kalp (2017) proposed A paper [11] that points out the disadvantages of a Conventional tractor that can perform one function at time. A prototype was designed which uses solar energy to perform the task and it also favored the use of Lead Acid Battery pack over Lithium-ion battery pack which had the Capability of functioning 3 farming processes in a single Run.

Sharma et al. [12] emphasized that electrification of agricultural machinery reduces fuel consumption and emissions while offering lower maintenance costs. However, limitations such as battery range and rural charging infrastructure still pose significant hurdles Addressing versatility, Kumar and Singh [13] proposed modular systems that allow a single vehicle to perform multiple tasks through easily interchangeable tools, making them ideal for small and medium-scale farmers.

Verma et al. [14] investigated the role of artificial intelligence (AI) in enhancing the performance of agricultural machinery. Their study demonstrated how machine learning techniques can be utilized to improve operational efficiency by accurately predicting soil health and identifying crop-specific needs. By leveraging data-driven insights, AI-based systems can support farmers in making informed decisions, thereby optimizing resource use and increasing productivity. In a related study, Singh and Rajan [6] focused on the development and deployment of electric tractors tailored for Indian farming environments. Their findings highlighted that compact, battery-powered tractors are not only technically practical but also cost-effective for farmers with smaller plots of land. These models offer an eco-friendly alternative to traditional diesel-powered machines, contributing to reduced fuel dependency and operational expenses.

Rapp et al [15] have studied the Land levelling for irrigation which is the process of modifying the surface relief by grading and smoothing to a planned grade and to certain specifications required to facilitate or improve the uniform application of water. It is the process of flattening or modifying existing slopes or undulations rather than necessarily creating a level surface as the name may imply. The journal tells about the benefits of levelling agricultural land. The advantages of the levelling process are better seeping of water into soil. The effect of this is that the crop yield increases exponentially.

P. V. Prasad Reddy and M. Yadi Reddy from the Department of Mechanical Engineering at Mahatma Gandhi Institute of Technology, Hyderabad, presented a paper in April 2021 [16] focusing on the development of a solar-powered multipurpose agricultural vehicle. Their work highlights how solar energy can be harnessed to operate various farming tools integrated into a single machine. The electric motor, powered by energy stored in batteries through solar panels, converts electrical energy into mechanical motion. This energy is then utilized to carry out essential agricultural activities such as water spraying, ploughing, and seed sowing. These operations are managed through a simple switch-controlled system, offering ease of use and efficient energy utilization for small-scale farmers.

Robertoes Koekoehk et al [17] have reviewed that farmers in India have opinions of the agricultural hand tools that they wear. In farming activities, they get injured due to the use of agricultural equipment's. The most injury was in hand. Farmers feel fatigue/discomfort in different levels of their body part when using agricultural tools. Majority of farmers complained to suffer fatigue in upper back (92.8%), mid back (93.6%), and lower back (91.8%), respectively. The third major criteria's design of agricultural hand tools base on survey resulted are safe, good and fit in hand, and easy to use. The ergonomic evaluation suggests their handle length and diameter to be 12.4 cm and 3.0 cm, respectively.

Patil and Joshi [18] presented a prototype of a hybrid multifunction agricultural robot capable of performing multiple field tasks such as weeding, spraying, and sowing. Their findings validated the potential of multifunction platforms to reduce labor dependency and streamline field operations.

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Shaikh Ajaharuddin G, Prof. P.G. Tathe (2018) proposed a paper [19] that point out the multitasking of the multipurpose vehicle, that is the two operations are multitasked in a single assembly. The vehicle was adopted with the scientific and precision forming technology and variable dimensions and farming specifications.

Literature studies indicate that multipurpose agricultural vehicles are highly beneficial for small-scale farms due to their ability to perform multiple tasks efficiently. Rahul Shukla and Sambit Mallick [20] conducted a study focused on the mechanization of agriculture, analyzing the challenges faced and the perspectives of researchers involved in the development of agricultural technologies. Their survey sheds light on how the scientific community is responding to the need for innovation in this sector. They emphasize that any transformation in the agricultural structure especially in terms of productivity and farmer income—must be evaluated alongside the implementation of modern, technology-driven farming solutions

III. PROBLEM IDENTIFICATION

Small and marginal farmers in rural areas often struggle with access to affordable, versatile, and eco-friendly machinery for daily agricultural activities such as plowing, seeding, spraying, and transportation. Traditional diesel-powered machines are expensive, polluting, and not multi-purpose, making them inefficient and unaffordable for small-scale farmers.

IV. APPLICATIONS

1. Crop Cultivation:
Electric vehicles can be used for plowing fields, towing agricultural equipment, and transporting produce around the farm.
2. Livestock Management:
They can be used for tasks like feeding, milking, and waste management in livestock farming, making them ideal for tasks like automated feeding and efficient milking processes.
3. Precision Farming:
These vehicles can be equipped with sensors and cameras to monitor crop health and identify issues, helping with early detection of pests and diseases.
4. Field Maintenance:
They can be used for tasks like soil levelling and irrigation, contributing to efficient and effective farm maintenance.
5. Transportation:
Electric utility vehicles can transport produce, tools, and personnel around the farm, making them useful for various transportation needs.

V. CONCLUSIONS AND FUTURE SCOPE

The Multifunctional Agricultural Electric Vehicle (MAEV) represents a significant step forward in modernizing agriculture through the integration of electric vehicle technology and versatile farming capabilities. By transitioning from traditional fossil fuel-powered machinery to electric-powered solutions, the MAEV helps reduce greenhouse gas emissions, offering a more environmentally sustainable approach to farming. It also presents cost-saving benefits through lower energy consumption and reduced maintenance needs. The vehicle's ability to perform multiple agricultural tasks, such as plowing, irrigation, planting, and harvesting, reduces the reliance on specialized equipment, thereby optimizing operational efficiency. Additionally, the integration of IoT and GPS technologies allows for precise farming practices, enhancing productivity and enabling smart farming. Overall, the MAEV stands as a powerful solution that addresses both environmental concerns and operational challenges in modern agriculture, driving a more sustainable and efficient future for the industry.

1. **Advancements in Battery Technology:** The future of MAEVs depends heavily on the development of more efficient, longer- lasting, and fast-charging batteries. Improved battery technology will extend the vehicle's operational range and reduce charging times, making it even more suitable for large-scale and remote agricultural operations.

2. **Autonomous Operation and AI Integration:** As autonomous technology and artificial intelligence continue to advance, MAEVs could evolve into fully self-operating machines. With the capability to perform tasks like crop monitoring, harvesting, and soil analysis without human intervention, these vehicles could further enhance farming efficiency and productivity.

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3. **Energy Integration with Renewable Sources:** The MAEV can be equipped to integrate seamlessly with renewable energy systems such as solar or wind power for charging. This will reduce dependency on the grid, lower operating costs, and further decrease its environmental impact, especially in rural and off-grid areas.

4. **Smart Farming and Data Analytics:** The future development of MAEVs can involve deeper integration with smart farming platforms. By leveraging IoT sensors, machine learning algorithms, and data analytics, these vehicles can optimize their performance, monitor environmental conditions in real-time, and provide farmers with actionable insights for more precise and efficient farming practices.

5. **Expansion of Multifunctionality:** Future models of MAEVs can incorporate more specialized functionalities such as advanced crop monitoring systems, autonomous pesticide spraying, and advanced irrigation techniques. This will allow farmers to address a wider range of tasks with a single, all-in-one vehicle, streamlining operations and reducing equipment costs.

6. **Global Adoption and Affordability:** As the electric vehicle infrastructure continues to improve and regulatory support for sustainable farming technologies grows, MAEVs will become more affordable and accessible to farmers across the globe, including in developing countries. This could lead to the widespread adoption of electric vehicles in agriculture, transforming the industry on a global scale.

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