Review Article

The Role of Modern Technology and Robotics in Enhancing Productivity and Sustainability in Agriculture

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Abstract

Agriculture plays a significant role in the global economy, serving as a leading sector in many countries. With a rapidly increasing world population, the demand for food in both quality and quantity has surged. To meet these escalating demands, it becomes imperative to implement transformative changes in agricultural practices. In conventional farming, a substantial workforce is traditionally required for various tasks such as soil nurturing, crop monitoring, pesticide and herbicide application, weed handling, irrigation, and harvesting.

Generally, in conventional farming, large number of human labours are required to doing in each and every task like nursing soil, monitoring crop, spraying pesticides, herbicides, weed handling, irrigation, harvesting etc but if we optimized our agriculture resources by Morden Technology, we can do smart and precise farming and bring a new revolution in the agricultural sector. In this study the authors have make efforts to summarised the need, function, purpose, statement, tool representation, advantages of robotics agriculture, use of agricultural robotics in India, automation and robotics changing the face of agriculture (Company), agriculture robots and farm robots, disadvantage of robotic agriculture. It is equally crucial to acknowledge and address the potential disadvantages of incorporating robotics in agriculture. Importantly, governments worldwide are actively endorsing and supporting research in agriculture through the formulation of policies, funding agencies, investment incentives, the provision of rebates and loans.

Agricultural robots are specifically designed to aid farmers in various tasks. These robots can be programmed to analyse, automate and perform repetitive and labour-intensive tasks. This capability not only alleviates the burden on farmers but also contributes to an overall increase in production and efficiency.

Keywords: Global economy, Conventional farming, Soil nurturing, Crop monitoring, Irrigation, Smart farming, Agricultural robotics, Automation, Revolution, Robotic Machine in Agriculture, IoT, CC, AIS, AIT.

INTRODUCTION

Robotics with Artificial Intelligence (RAI) plays a vital role in agriculture. Robotics and AI use in agricultural tools are called Agricultural Robotics (AR). AR has lot of application in many different fields of agriculture and associated field like: drones for weed controlling, fruit picking, plant seeding, horticulture, sheep shearing robots, environmental assessing, monitoring of soil, weather condition, automated washing, automated spraying, soil mapping and analysing etc [1-9].

As per the growth of population, food consumption is increasing rapidly so researcher, scientist, farmers, government and different stakeholders must focus on Morden Information Technology (MIT) like [10-17].

a)   Agriculture Information System (AIS).
b)   Agriculture Information Technology (AIT).
c)   Agriculture Computing (AC).
d)   Robotics (R) with Artificial Intelligence (AI).
e)   Internet of Things (IoT).
f)   Computer Vision Technology (CVT).
g)   Unmanned Aerial Vehicle (UAV).
h)   Global Positioning System (GPS).
i)   Remote Sensing (RS).
j)   Image Recognition Software (IRS).
k)   Cloud Computing (CC).
l)   Prig Data & Analytics.
m)   HCI & HCC.
n)   Usability Engineering and UXD.
o)   Global Information System (GIS).
p)   Simulation Software (SS).
q)   Automation.
r)   Information & Communication Technology (ICTS).
s)   Digital Farming (DF).
t)   Aerial Imaging (AI).
u)   Early Warning System (EWS)

Some of the vital roles of ICT in Agriculture are:
a)   Environmentally Sustainable Agriculture (ESA).
b)   Agriculture Extension and Advisory Services (AEAS).
c)   Regulatory Policy & Governance (RPG).
d)   Enhanced Market Access (EMA).
e)   Early Warning System (EWS) for Disaster Management.
f)   Food Safety & Traceability (FST).

Agriculture plays the most significant role in economics sector in India. Various countries of the world, a large percentage of population is dependent on Agronomy (A). Nearly 65% economy comes from agriculture but farmers face many challenges due to lack of technological awareness, implementation and their economic condition. Human labours are required at every stage of farming which increases the expenditure, increases the time to complete task and also increase probability of error and wastage which affects the quantity and quality of crop.

Life depends on agriculture because it provides the necessary means of living like (foods, drinks, cloths, etc). To beat the needs of the estimated 8-9 billion people till 2050, agricultural scientists, farmers, growers must find sustainable ways to produce more food from deficient land. The use of automation, mechatronics and robotics has greatly enhanced agricultural output by improving effectiveness, efficiency, dependability, accuracy and minimizing human interferences [18-21].

A robot is a mechanical artificial agent that works electromechanically. Robot is intimated with software programming that can does complicated task easily in agriculture.

In field of agriculture, farmers can use robotics technology for different purpose of tasks like planting, spraying, weeding, harvesting, post-harvest activities and so on [22].

Agricultural robots and its associated technology business will grow at 35$ billion within 2025. AR can perform the work with efficiencies, enhance productivity, minimized the product expenditure and cost, minimize labour expenditure, helps in harvesting, reduce manpower involvement and many other tasks.

The Developed and developing countries like Germany, Ireland, South Korea, China, India and even few countries from Africa are using agricultural robotic in their farming.

The development of modern technology has brought the robotic system and AI in the agriculture sector that helps to increase productivity and efficiency [23].

Agriculture robotics is an emerging field that brings a new revolution in traditional agriculture. It enhances crop production efficiency and contributes to maintain farming integrity. Robotics in agriculture has to potential to manage various challenges including labour shortage, resource, time management etc.

Due to labour shortage or urgent demand of food for the global population in crisis agricultural robots should be common to each and every farmer.

Agriculture is undergoing on Evolution Technology (ET) is becoming an indispensable part of every commercial farm. New agricultural company is developing technology that allow the farmers to maximize yields by controlling every important variable of crops farming such as moisture levels, all condition microclimate, ect.

The introduction of agricultural robotics enhanced productivity, reduced labour intensive task, promote sustainable farming, automation weeding to precision, seeding and harvesting. Agricultural robots are revolutionizing at agricultural scope in India and different parts of world. As technology increases, the role of robots will also increase in the farming sector, which reduce the challenges of farmers and also ensure food security for the growing population [24-45].

This paper give clear insight for promoting knowledge to agricultural concerning persons, scientist, researchers, stake-holders, government, industrialist, NGO'S, private and different industry, company, for the last people of every citizen of world to explain utilization of robotics machine in agriculture [Table 1], advantages of robotics agriculture (ARA) [Fig. 1], functions of agricultural robotics in India (FARI) [Fig. 2], different Indian company for agricultural robotics (DICAR) [Fig. 3], changes of countenance of automation and robotics in agriculture (CCARA) [Fig. 4], agricultural robotics and farm robotics (ARFR) [Fig. 5], disadvantages of robotics agriculture (DRA) [Fig. 6].

Mobile Robot for Agriculture [MRA]: Mobile robot can perform multiple tasks like obstacles avoidance, tracking, path planning, crop data collection, disease detection autonomously with reduced hardware for low-cost robot & used mostly by the farmers.

Smart Robot for Agriculture [SRA]: SRA can make forward, reverse, left, right, SRA can be used in ploughing, seed sowing, watering, obstacle detection, obstacle clearance.

Nano Robot for Agriculture [NRA]: NRA has wide area of application from agriculture to security, environmental protection, allow robot operation to sense how much pesticides are being applied to crops. Titan robot uses AI technology & it travels through agriculture fields, takes picture of the soil & creates 3D model in real time. Nano robots can be used in precision agriculture by monitoring soil, crop condition at a micro level. NR can collect data soil moisture, Nutrient levels, plant growth, crop production, soil remediation, harvesting, reduce waste & increasing efficiency.

Table 1: Utilization of Robotics Machine in Agriculture [3-5,7-9,12,24,25,29,33,38,45,47-53]

Sl. No.	Purpose	Statement	Tool Representation
1	Soil Sampling	"Smartcore" an Automated Robot Collecting Soil Samples (ARCSS).	
2	Seeding	Robot Developed by Indian Agricultural Research Institute (AGRI).	

3	Transplanting	A Tree Planting Robot (TPR) named "Tree Rover".	
4	Weeding	Robot named "Evo" doing weeding work in the fields.	
5	Weeding	A Robot working in the vineyard named "Ted".	
6	Weeding	A Universal Mobile Platform for Agriculture "PUM-Agri".	
7	Weeding	A Robot Developed in Japan working in paddy field "Duck".	
8	Pruning	A Robot working in Vineyard.	

9	Harvesting	Octinion's, A Strawberry plucking robot.	
10	Mowing	iRobot Automatic Mower.	
11	Phenotyping	This robot collect phenotype information at the farm Robot named "Ira".	
12	Multipurpose prime mover	A Universal Mobile Platform for Agriculture "PUM-Agri".	
13	Poultry	A Robot developed to look cattle-farm named "Swagbot".	
14.	Demeter	For Harvesting Purpose.	

15.	Forester Robot	It is a semi-autonomous system that can perform forest regeneration operations.	
16.	Robot in Horticulture	Horticulture Robot can be used in Sowing, Transplanting, Weeding, Disease Control etc.	
17.	Fruit Picking Robot	Fruit Picking Robots are autonomous robots that use sensors and cameras to detect when crops are ready to be picked.	
18.	Crop Harvesting Robot	Crop Harvesting Robots are designed to harvest fruit and vegetable.	
19.	Harvest Automation	Harvest Automation is a robotics company that manufactures small mobile robots for material handling.	
20.	Weeding Robot	Weeding robots use AI, robotics and agriculture technology to identify and eliminate weeds from fields.	

21.	Naio Technology	Naio Technology is a company that develops and sells robots for agriculture and viticulture.	
22.	Nexus Robotics	Nexus Robotics is an agriculture solution company that develops robot and AI for Vegetable production.	
23.	Merlin Robot Milker	A robotic milking system that allows cows to be milked 24/7.	
24.	Orange Harvester	Orange harvester are machine that produce fruit.	
25.	Lettuce bot	Lettuce Bot is a robot that uses computer vision and robotics to identify and thin lettuce plant.	
26.	Weeder	A weeder is a tool or machine used to remove weeds from a garden or lawn.	

27.	Solar Robot	A cost effective and sustainable solution for farmer providing them with a way to improve their productivity and reduce their environmental footprint.	
28.	Agriculture Robot Suit	The Tokyo University of Agriculture and Technology has developed an agriculture robot suit designed specifically to help out with tough agriculture work like pulling radishes.	
29.	Mobile Robot	Crop data collection, disease detection, obstacles avoidance.	
30.	Smart Robot	Ploughing, seed sowing, watering, obstacles detection & clearance.	
31.	Nano Robot	Monitoring crop protection, Nutrient level plant growth.	

Fig. 1: Advantages of Robotics Agriculture (ARA)

Fig. 2: Functions of Agricultural Robotics in India (FARI)

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Fig. 3: Different Indian Company for Agricultural Robotics (DICAR)

Fig. 4: Changes of Countenance of Automation and Robotics in Agriculture (CCARA)

Fig. 5: Agricultural Robotics and Farm Robotics (ARFR)

Fig. 6: Disadvantages of Robotics Agriculture (DRA)

Issues and Suggestion

AR are much popular globally due to variety of distinct nature and qualities but we have to focus on different problems due to use of these modern technologies [46]:

1) Periodic maintenance is required in RA to ensuring their productivity and utility.
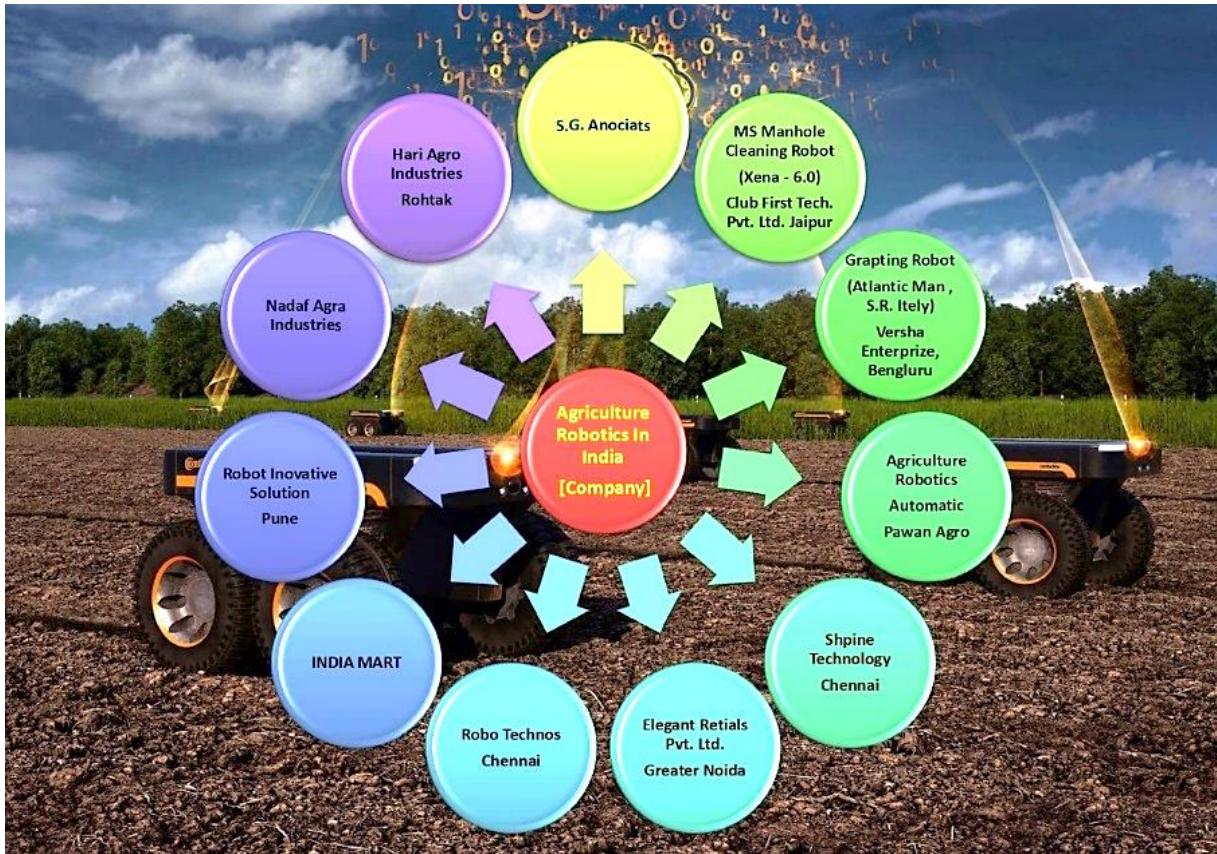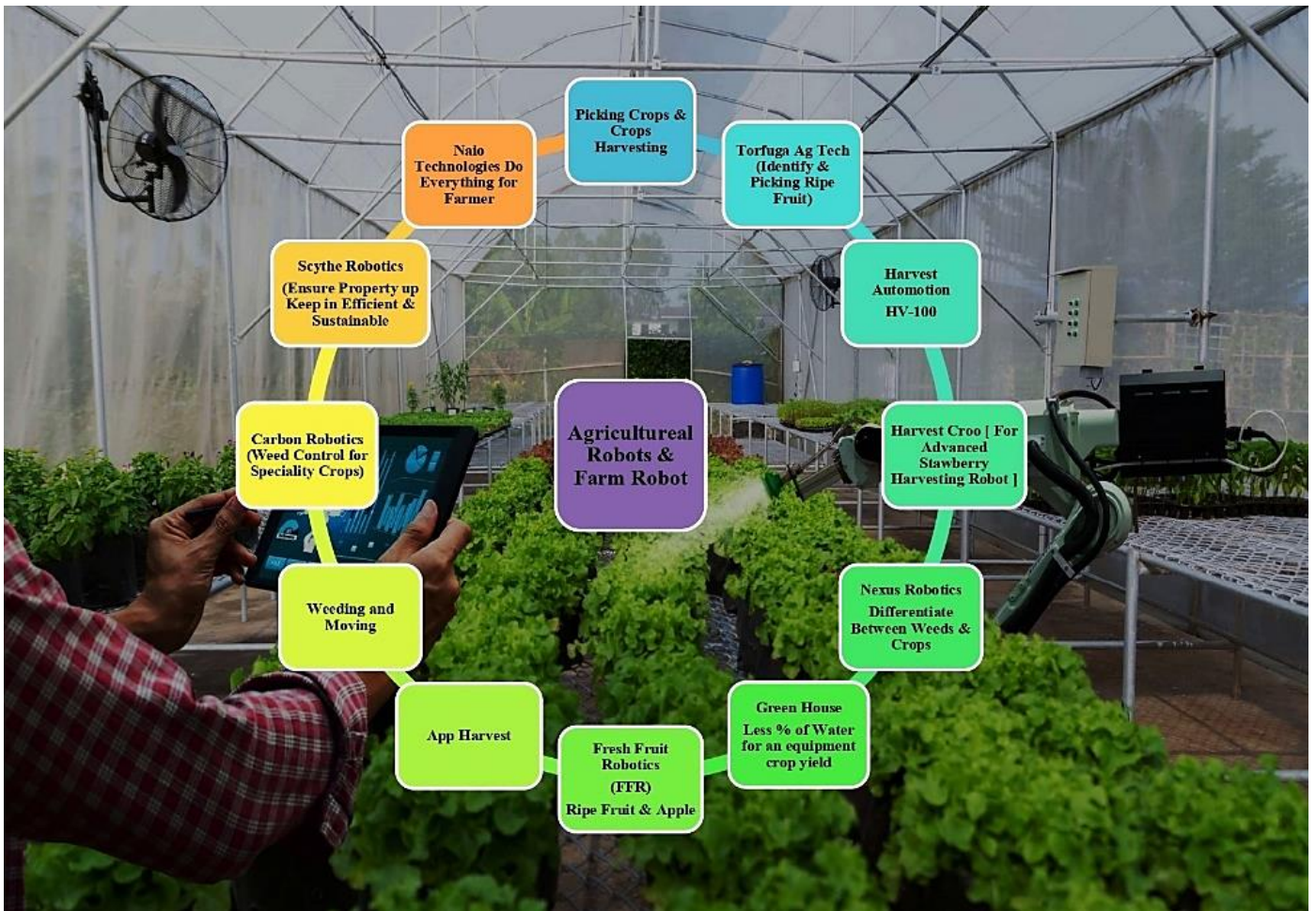2) Adequate people is required for their development, repair and advancement, so primary education and knowledge is required.
3) Research and development are required because a particular robot can perform only a particular work.
4) Farmers should be trained for their functional operations and management.
5) AR are more expensive than traditional farming so, many NGO'S and Charitable trust invest on it also banks and government approve loan at low interest rate to promote AR.
6) Proper Orientation programme, training on AR must be provided to agricultural farmers by different Scientist/ Researchers/ Skilled Fellows.
7) The information technology (ICTS) mentioned in the paper must reach to even the remote location to help farmers & focus in updating latest crop cultivation process.
8) Agriculturists can connect with the local network of farmers, agronomists, business & other service providers to stay up to date on the latest farming.

CONCLUSION

It is necessary to work with modern techniques for crop production in future time so that production growth will fulfil necessity of population of India and world within less time, better efficiency, low labour expenditure, eco-friendly and convenient manner.

AR is a result of advance technology, it accomplishes not only soil testing, weather monitoring but also sowing, planting, weeding, pruning, fruit plucking, ploughing, harvesting, phenotype weeding, fruits harvesting and many more. AR is more efficient than human in many social & public platforms. Robotic Sector (RS) is emerging market in agriculture and economic sector. It is a great means of jobs and self-employment generation in the country. Robots will definitely prove helpful in attracting the younger generation to agriculture and increasing agriculture production.

Acknowledgement

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