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An Analysis of the Implications of the Fourth Industrial Revolution in Production/Supply Chain Management for Agricultural Producers in Developing Economies

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Abstract

This paper provides a conceptual overview of various developments of the fourth industrial revolution (4IR) and presents these developments in agricultural production/distribution in the context of supply chain management (SCM) in developing countries context. This paper defines 4IR as the merging of technologies and interactions at the physical, digital, and biological levels. Specifically, it examines developments related to the Internet of Things (IoT), blockchain technology, robotics, Big Data analytics, biotechnology, nanotechnology, 3D printing, and artificial intelligence that aim to ensure sustainable production and SCM in agricultural production/distribution. The paper concludes with a hypothesis on what farmers in developing countries should do to meaningfully benefit from 4IR.

Keywords: Fourth Industrial Revolution, Supply Chain Management, Agriculture, Developing countries

Introduction

The growth in the production of goods and services is mainly the result of changes in the technologies used. (Ageron, Bentahar, & Gunasekaran, 2020; David, Nwulu, Aigbavboa, & Adepoju, 2022). Since time immemorial, people have tried to increase production through improved technologies and structural changes. Industrial revolutions are one of the main areas of much discussion at present (Koh, Orzes, & Jia, 2019; Luz-Tortorella et al., 2022, , Turner, 2024). This paper traces the development of these technologies from the pre-industrial (agrarian) revolution, identifying the driving forces and their impact on economic, social, political and structural changes. With regard to the fourth industrial revolution (4IR), the paper specifically charts the way forward for developing countries, especially for agricultural products in the developing countries.

Objective, Significance and Methodology

The main objective of this study was to track developments in the 4IR and map those developments in the production/supply chain management in developing countries context. Primarily the work used methodology proposed by Reese (2022). This article provides a guide to this task, focussing on the process of concept explication - the development of theoretical concepts with careful consideration of the interplay between their definition and measurement and link together in a broader theoretical argument.

Climate change, global population growth, high levels of food waste and loss, and the risk of new disease or pandemic outbreaks are examples of the many challenges that threaten the future sustainability of agricultural production/supply chain management. This review paper summarises the key technologies of 4IR. Despite the importance of each of the above technologies in isolation, breakthrough sustainable solutions can only emerge through the

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simultaneous combination of many technologies. The era of agricultural production/supply chain management is characterised by new opportunities, challenges, opportunities and trends that need mitigated.

Writing about 4IR in supply chain management within the agricultural sector in developing countries plays a crucial role in knowledge dissemination, policy advocacy, capacity building, research and innovation, socio-economic development and global co-operation. By documenting experiences, sharing insights and promoting dialogue, the authors help to unleash the transformative potential of technology for sustainable agriculture and inclusive development. Some areas include: Knowledge dissemination, policy advocacy, capacity building, research and innovation, socio-economic development, global cooperation and others.

Industrial Revolutions

Technological developments usually occur in three forms. Small changes are usually versions or variants, and in many cases the producers of such technologies define versions/variants. The second classification of technological development is a generation. A generation occurs when two or more technologies merge. The last developments is revolution. A revolution means great upheaval/change. It is different from evolution, which is a process that triggers the development of different types of living organisms/processes from earlier forms throughout Earth's history. Evolution can preserve much of the status quo, whereas a revolution challenges it. Industrial revolutions involve radical improvements in technology and drastic socio-economic, political and structural changes in societies triggered by these technological advances. There are four phases of industrial revolutions from the first to the 4IR, using the early production processes (agricultural revolution) as a starting point. The developments of various industrial revolutions is summarized in Appendix 1.

Technologies Involved in 4IR and Their Impact on Agriculture

Internet of Things (IoT)

The Internet of Things (IoT) for supply chain management in developing countries can be defined as a network of interconnected physical devices that collect and share data across the supply chain. This data can be used to improve efficiency, transparency and sustainability, specifically tailored to the challenges faced in developing countries. The IoT describes various tools that can be used in daily life to monitor the physical location and condition of users. With the IoT, companies can collect data to determine how customers use products and adjust marketing campaigns accordingly. There are many industrial applications, such as farmers placing IoT sensors on their fields to monitor soil properties and make decisions about when to fertilise the soil. IoT can use sensors for weather forecasting. This data can be analysed accurately to plan for weather changes. Sensors can collect data on temperature, humidity, moisture precipitation and dew formation in a farm. Analysis of this type of data helps in the correct allocation of crops to be grown on these areas.

Most of the current research on IoT is on surveys (Laghari et al., 2022; Jumbri et al., 2024; Nguyen, et al., 2022; Koohang et al., 2022) and they are also on the rise in agriculture. The IoT is developing rapidly to enable smart agricultural production. This technology can connect different types of agricultural equipment, which can collect data and send it to servers for analysis. These tools help farmers optimise crop production. However, one of the main problems in agricultural areas is the lack of connectivity or poor connection quality (Yascaribay et al., 2022, Rastegari et al., 2024). Nevertheless, IoT-based solutions for agriculture can improve farmers' decision-making processes regarding crop fertilisation (Phasinam, Kassanuk,

& Shabaz, 2022; Akkem et al., 2023). In another study (Tangwannawit & Tangwannawit, 2022), maize was tested in Thailand by installing 20 IoT devices consisting of soil moisture sensors and temperature and humidity sensors. The algorithm obtained helped write a function to control the automatic irrigation system to ensure that the temperature and humidity remain at appropriate conditions for maize cultivation. By using the improved irrigation system, the efficiency of the irrigation system was improved by saving water.

Blockchain Technology

A blockchain is a digitally distributed, decentralised, public ledger that exists on a network. It is a system for recording information that makes it difficult or impossible to change, hack or defraud the system. In the context of supply chain management for developing countries, blockchain technology can be understood as a secure, shared database that enables all parties involved to transparently track goods and information. The blockchain makes it possible to monitor crops and livestock from growth to sale to suppliers. This would make it possible to trace the supply chain of a product if it turns out to be faulty. This safeguard eliminates the inconvenience of blocking a country's entire supply chain, as only one faulty supplier would be the focus of intervention. Moreover, such a contingency plan eliminates concerns about trade wars and political tensions.

Blockchain technology enables tracing the origin of food and prevents counterfeit raw materials from entering the production line (Alobid, Abujudeh, & Szűcs, 2022; Kamble, Mali, & Patil, 2022). Blockchain can also improve production and distribution processes (Mavilia & Pisani, 2022; Albaaji & Chandra, 2024; Yang et al., 2023; Agrawal et al., 2024). Blockchain in smart agriculture includes four aspects: distributed farming system, smart transportation, blockchain application in product trade, and agricultural insurance (Huang & Zhang, 2022).

Robotics

Robotics refers to the design, manufacture, and use of robots for personal and commercial use. Robots are adaptable and flexible, and their structural and functional design is inspired by complex biological structures. Advances in sensing technology are enabling robots to better understand and respond to stimuli in the environment and to perform a broader range of tasks, such as household tasks. Unlike in the past, when they had to be programmed via an autonomous unit, robots can now access information remotely via the cloud and connect to a network of other robots. For supply chains, robotics can include different types of machines, such as automated guided vehicles (driverless vehicles that transport goods within warehouses or factories), picking and packing robots (machines that perform tasks such as selecting items from shelves or placing them in parcels) and warehouse management robots (autonomous systems that track and monitor stock levels). These solutions are generally cost-effective, adaptable and low-maintenance in developing countries.

Robots - whether fully automated or semi-automated with arms - can perform a wide range of tasks. These include spotting weeds and spraying pesticides in infested areas, saving an infested crop and the cost of agrochemicals that might otherwise have been spent on the whole farm. They can also be used at harvest time. The hypothesis is that the use of robots in agriculture can further revolutionise agriculture (Padhiary et al., 2024; Khadatkar, Mehta, & Sawant, 2022), including in the harvesting of fruits, pest control and crop management (Kondoyanni et al., 2022).

Big Data Analytics

The need to be efficient is when you have enough information that requires a high ability to work with it to get exactly what the business needs. Big data analytics refers to the process of extracting valuable insights from large and complex data sets generated throughout the supply chain. Every digital process and social media exchange generates data. Systems, sensors and mobile devices transmit this data. Big Data comes from multiple sources with high velocity, volume and variety. Getting meaningful value from Big Data requires optimal processing power, analytical capabilities and information management skills that require the use of modern tools such as computers and other electronic devices to produce effective results.

Several research papers (Arab, et al., 2022; Thandekkattu, Vajjhala, & Dzarma, 2022; Wang et al., 2022) have dealt with Big Data analytics. Big Data analytics supports crop growth monitoring, yield forecasting, land suitability analysis, forest productivity and drought assessment in crops, vegetables and fruits (Farooqui et al., 2024; Ahamed, 2022). Information sharing in supply chain management improves effectiveness of the processes (Ayele & Ram, (2023).

Biotechnology

Biotechnology is a field of biology that uses living processes, organisms or systems to produce products or technologies designed to improve the quality of human life in supply chain systems. Biotechnology is not new, but the development of technologies that enable rapid and massive data analysis has given the technology new momentum and impetus. Biotechnology is attracting a lot of attention because of the benefits associated with it. These benefits include the reduction of waste in the production of palm oil, rubber, wood processing plants and livestock manure (Sivakumar et al., 2022; Doelle et al., 2023). Biotechnology has also enabled cucumber and orange strips, which have recently been used to produce proteins and bioenzymes (Sivakumar et al., 2022). However, the application of biotechnology raises some ethical issues (Kendig, Selfa, & Thompson, 2022; Al-Delaimy, 2022; May et al., 2022), such as the availability and use of privileged information, the potential for ecological damage, and the prospect of interfering with nature. Nevertheless, the use of biotechnology improves agricultural production (Gurjar, 2022).

Nanotechnology

Nanotechnology is the science of designing, manufacturing and using structures and devices with one or more dimensions of about 100 millionths of a millimetre (100 nanometres) or less. Some research articles have addressed the prospects and problems of nanotechnology in agriculture (Muraisi et al., 2022; Pandey et al., 2024).

3D Printing

3D printing allows manufacturing companies to print their own replacement parts with fewer tools, at a lower cost and faster than traditional methods. In addition, designs can be customized to ensure a perfect fit. This technology is available for a wide range of applications, from large (wind turbines) to small (medical implants). Currently, it is mainly limited to applications in the automotive, aerospace and medical industries. Unlike mass-produced products, 3D-printed products are easily customizable. As current size, cost and speed limitations are gradually overcome, 3D printing will become more widespread to include integrated electronic components such as printed circuit boards and even human cells and organs.

3D food printing is the process of producing food using a 3D printer. 3D food printing is an innovative technology that has the potential to revolutionise the way we prepare and consume food. It offers exciting opportunities for customisation, creativity and even personalised nutrition. Some use it for artistic presentations, but 3D printing can also be used to produce food with special textures or personalised nutritional value. Examples of 3D printing in agriculture include food engineering, where unique food products with enhanced sensory and nutritional value are produced for a specific end user (K-Handral et al., & Choudhury, 2022; Sánchez-Gil et al., 2024; Portanguen et al., 2022; Liu, et al., 2022; Pan, et al., 2022; Padhiary et al., 2024, Enfield et al., 2023).

Artificial Intelligence

Artificial intelligence or simply AI refers to computers that can "think" like humans. These computers can recognise complex patterns, process information, draw conclusions and make recommendations. Artificial intelligence is used in many ways, from recognising patterns in vast amounts of unstructured data. It supports smart agriculture based on precision agriculture (Sharma, Georgi et al., 2022; Shaikh, Rasool, & Lone, 2022). Agriculture faces challenges such as plant diseases, lack of irrigation, water management problems, environmental damage, low yields and improper soil treatment, the solution of which can benefit from the application of artificial intelligence (Sarkar et al., 2022). Both knowledge-based systems (expert systems and neural networks) could be applied in agriculture to alleviate farmers' problems and increase their yields (Zatsu et al., 2024; Thapa et al., 2023; Bali & Singla, 2022; Zhao & Jia, 2022; Reddy & Fields, 2022).

Implications for Farmers in Developing Countries

Developing countries are generally keen on 4IR, especially in the agricultural sector, which employs most of the population. The productive youth are now pushing into the service sectors of the economy. Despite the many efforts made by the governments to support the backbone of the economy, many bottlenecks hinder the full realisation of the 4IR potential in the agricultural sector.

First of all, many countries have barely managed to move beyond the second industrial revolution phase. This is evidenced by the lack of access to electricity in some areas and the fact that manual labour is still used instead of highly mechanised heavy and efficient machinery to enable mass production in the agricultural sector. As a result, the benefits of 4IR are still far from being realised, especially when it comes to commercial application. Furthermore, the lack of access to a powerful internet hinders the widespread application of IoT in many developing countries.

The 4IR would bring both promising and detrimental changes to the economies and societies. On the one hand, the benefits would be improved food security due to adequate production and storage through biotechnology. In addition, there would be adequate nutrition due to the ability to grow numerous crops efficiently (through internet of things), more tax revenue (through blockchain technology) for the treasury as more crops would be grown on a large scale, and an improvement in the volume of trade and balance of payments due to the export of surplus food coupled with increased foreign exchange earnings. These are indeed some of the certain benefits that would result from such an abrupt change

On the other hand, the 4IR application would be a huge disruptive factor even in supply chain management (Ajayi & Laseinde, 2023; Kruger & Steyn, 2024; Putthakosa & Luong, 2023; Nilakantan, 2022, Zhou et al., 2022, Mwanza & Telukdarie, 2022). With the proportion of people employed in agriculture decreasing year by year, the introduction of the 4IR could lead to a drastic decline. This would lead to massive unemployment and have far-reaching implications for many countries. Finally, the 4IR is capital intensive (like quantum computers), which means that many agricultural workers will inevitably become unemployed, as some lack even the basic skills to move into other sectors. In other words, the full exploitation of this kind of change requires huge tracts of land to yield the required dividends. This means that many rural dwellers will have to leave their land to make way for these huge agricultural investments. In addition, land disputes and the lack of personal food security could create a sense of insecurity among some citizens.

Positive Implications

The integration of current 4IR technologies into the management of the agricultural supply chain in developing countries can significantly increase efficiency and productivity. Some examples are explained below. For example, the use of IoT sensors on farms and along the supply chain can provide real-time data on crop health, soil moisture, temperature and humidity. This data enables farmers and supply chain managers to make informed decisions about planting, harvesting and distribution, leading to improved efficiency and resource utilisation. In addition, the use of data analytics and predictive modelling algorithms can help identify patterns, trends and potential risks within the agricultural supply chain. By analysing historical data and current trends, stakeholders can optimise production plans, inventory management and transport routes, leading to cost savings and greater efficiency.

Using drones to monitor crops, livestock and infrastructure can provide valuable insights into crop health, pest infestations and infrastructure damage. Drones equipped with cameras and sensors can quickly identify areas that require attention, allowing for timely intervention and preventing potential losses. The introduction of robots for labour-intensive tasks such as planting, harvesting and sorting can help alleviate labour shortages and reduce production costs. Robotic systems can work efficiently around the clock and increase overall productivity and throughput on farms.

Increased Productivity, Enhanced Resilience of Agricultural Breeds and Significant Reduction in Operational Costs

Optimising essential 4IR technologies can translate into higher crop and livestock yields. Indeed, more can now be produced per acre than ever before. Such technologies also eliminate overdependence on rainfall while keeping pests at bay. More and better food could also lead to improved food security and increase the incomes of stakeholders at every stage of production. Such a development would be positive for countries where some droughts have been observed or predicted (Busker et al., 2023; Ayugi, et al., 2022; Nakao, et al., 2022; Ochieng, Nyandega & Wambua, 2022). The adoption and application of the 4IR and related technologies could revitalise crop and livestock breeds, making them more resilient. Reduced vulnerability to drought, pests, diseases and other sudden natural disasters improves people's ability to adapt to future contingencies (Albahri et al., 2024; Bislava et al., 2022), such as shortened seasons and problematic weather patterns. Typically, the 4IR interrupts many employment opportunities to reduce operating costs. Inventions related to computer imaging, drones and robotics have saved farmers a lot of money. The savings relate to labour, monitoring, treatment and harvesting costs. The reduced expenses mean huge savings that can be put into expanding production. Instead of employing farmers to monitor crops, drones and computer imaging are useful.

Better Quality Produce and Ensured Sustainability

Agricultural products and their quality have improved significantly with the advent of the 4IR. The use of computer imaging, drones and IoT make this possible. When crop production shows signs of deterioration in the form of low moisture and the appearance of pests, the data is quickly relayed to the farmer so he can take action. Drones help neutralise the appearance of pests, and activated irrigation sprinklers balance moisture levels in an instant. Consequently, the application of this technology guarantees better quality produce (Sagandira, et al., 2022; Nyagadza et al., 2022). Precision agriculture ensures farm sustainability through efficient use of resources for crops and livestock (Zaman, 2023; Farooqui et al., 2024). By conserving resources such as irrigation water and efficient land use, the pressure that agriculture places on planet Earth is reduced. While the world is currently implementing the 4IR, some parts of the world have already begun to enforce the principles of the fifth industrial revolution.

The Rise Use of Sensors in Determining Customer's Preferences

Due to the high use of artificial intelligence, sensors will be used extensively in the future fifth industrial revolution to detect customer preferences and derive market trends that will help marketers plan and implement the right marketing strategies. many industries have seen the introduction of new technologies that enable new ways of meeting existing sourcing needs and enable them to compete with renowned production and value chains around the world. A similar consequence is emerging from the initiatives of disruptive competitors that rely on global digital platforms for research, development, marketing, sales and distribution and can quickly displace long-established and incumbent players by improving the quality, speed or cost of delivery of consumer goods. The increasing availability of information, the constant involvement of consumers and new patterns of consumer behaviour (especially through access to mobile networks and information) are forcing companies to adapt the way they develop, market and deliver products or services, gradually leading to significant changes on the demand side.

4IR Will Enhance Marketing

Generating large volumes of market data requires high data storage in cloud computing, which will completely change market dynamics and analytics. Therefore, farmers should meaningfully benefit from cloud computing by using the data on the cloud server to generate market analytics aimed at improving personalised marketing strategy. Advances in quantum computing and artificial intelligence data collection mean that farmers have a wealth of data about their target audiences at their disposal. Demographic and psychographic information is collected and used by software such as social media analytics tools.

4IR Will Foster Collaborative Innovation and New Operating Models

Collaborative innovation is a process that enables individuals or companies with different interests to work together to develop new products and can occur in any context of a business cycle, such as research and development. Collaborative innovation creates shared ownership through the implementation of innovative ideas, which helps to spread risk across multiple actors. It also stimulates employee productivity and overall problem solving. Indeed, collaborative innovation approaches go beyond marketing and distribution arrangements. The 4IR is driving companies to find ways for online and offline worlds to work together simultaneously. The justification for the topic of operating models stems from the fact that operating models have a significant impact on the achievement of business objectives. All of these impacts require farmers to rethink their operating models, with strategic planning proving critical in enabling companies to move faster and more agile than before.

It is clear that successful farmers will increasingly move away from traditional hierarchical structures towards network and collaborative models. The motivation for such advances will increasingly be intrinsic, as they will be based on the shared desire of farmers for mastery, independence and meaning. In other words, farmers will increasingly organise around remote workers and dynamic collectives with a continuous exchange of data and insights about needed things or tasks. The rapid evolution of technology associated with the IoT is enabling farmers to merge the digital and physical experience to benefit consumers or buyers and workers simultaneously. Mechanised machines and tools in various industries such as software and robotics have ensured that wearables help in the development and repair of components. Downloads and updates for the machines ensure that both the workers and the capital goods are kept up to date.

Data Enhanced Product

Under 4IR, the performance of farmers in this technological era can be tracked using data collected from customers, which would improve performance, for example, by using enterprise resource planning tools to develop data for productive use in an organisation through data analytics. Farmers can collect information on customer demand at low cost but with high efficiency, providing innovative ideas for research and development of new products. Through data-driven farming in the 4IR, a farmer can create and enhance the value of customers to sell its products and increase its profits. For example, data-driven products can create a business that describes how farmers create and deliver value to customers and then convert the payments they receive into profits (Zhou et al., 2022; Latino et al., 2022, Takhar & Liyanage, 2021).

The 4IRs support improved data products through numerous innovations to reduce the operating costs of certain production processes for consumers, who would also receive greener products as a result. For example, Tesla electronic cars were developed as a product of the 4IR because there is a lot of data about cars that changes car production with connected networks in the car (Gianolli, 2020). By acquiring this information, managers get the opportunity to develop some customer-oriented products.

Negative Implications/Challenges

Not all developing countries are the same when it comes to implementing 4IR in supply chain management. The differences stem from various areas such as electricity, where some technologies such as advanced robotics, blockchain technology and big data processing require constant access to reliable energy sources that are not readily available in all regions. The ability to leapfrog also varies from developing country to developing country, as some countries have a culture that supports technology adoption while others do not. This means that the differences are not equal.

Inadequate Mobilisation of Capital

The 4IR and its associated technologies and technical know-how require a lot of money. In this regard, the lack of assets, inadequate identification of clients and weather uncertainties make the agricultural sector unattractive to lenders, which also discourages 4IR. Many developing countries are not yet fully electrified. Despite recent efforts to electrify the entire region, the goal is still largely unachieved. Yet the available electricity is too inadequate to power the equipment needed for efficient production. This low-voltage electricity makes it difficult to apply the 4IR technologies, let alone the 2IR needed for mass production.

Less and Weak Network Coverage

Many developing countries are not yet fully served by telecommunication networks, especially in rural areas where agriculture is practised. However, in the areas where there is network coverage, it is inadequate. There are many network failures and huge data latency. This limits the effective use of innovations such as IoT and computer imaging and leads to a delay in data transmission. This scenario restricts proper communication and can lead to losses when immediate decision making is required. Farmers may be are faced with large amounts of data, in a variety of formats, generated at an ever-increasing rate as more and more companies become dependent on the use of artificial intelligence. To cope with these volumes of data, artificial intelligence algorithms need to be easy to understand. These algorithms should also be able to combine different types of data from different time periods.

Low Levels of Education and Exposure Among Citizens

For numerous reasons, many countries do not finish their educational careers until after they have completed their basic education. As a result, they lack knowledge that they could otherwise have acquired in higher levels of education, making them unaware of the lucrative opportunities available. The absence and inefficiency of agricultural extension officers also rounds up the problem. The officials would not even disseminate the basics, let alone the 4IR. The extension officers' knowledge of 4IR could also be inadequate and would need to be brought up to date to cater to the farmers who get their hands on this technology.

Data sensitivity and Security

The growth of technology means that the protection and management of intellectual property is becoming increasingly important. Data should test and train the artificial intelligence algorithm to implement it successfully with shared data. However, current data management policies and requirements used internally in an organisation do not support cross-organisational data sharing and most organisations are reluctant to do so with third-party developers. Recent vulnerabilities in factories are increasingly threatened. Real-time interoperability results from smart factories consisting of digital systems, which in turn pose a high risk for an extended attack platform. Finally, numerous devices connected to one or more networks in a smart factory can trigger vulnerabilities. Therefore, companies should anticipate both machine-level operations and enterprise system vulnerabilities to overcome such a crisis when it occurs.

Interoperability

The lack of separation between components and systems hinders the ability of most companies to innovate. Interoperability also limits the possibilities for upgrading system components, as they cannot simply replace one component of the system with another.

Access to Cutting Edge Technology is Limited

Access to cutting-edge technologies and research is often limited in developing countries. This can prevent them from keeping up to date with the latest advances in 4IR and utilising relevant technologies to improve agricultural supply chains. Many 4IR technologies have been developed in the context of advanced economies and may not be directly applicable to the unique challenges and circumstances of developing countries. Adapting these technologies to local conditions while ensuring affordability and accessibility is critical, but can also be very complex.

Conclusions and Recommendations

The 4IR is both a blessing and a curse, not only for farmers in developing countries but also for the world. It is the only revolution that is progressing faster than any other revolution before it. Moreover, the revolution encompasses almost every aspect of human life and is therefore inevitable. We cannot ignore these changes. To ignore them would come at a high price. Yet they are of great benefit, especially in the face of rapid population growth that is putting pressure on the scarce resources of planet. It is about integrating 4IR into people's lives to ensure that they get the most out of what is available. Nonetheless, people should try their best to mitigate the burdens that come with such technological advances. People should build capacity in various areas to help citizens navigate the agriculture with ease. Otherwise, the 4IR could lead to social discord and instability as many people would become unemployed and displaced without hope for a better future.

Conclusion

In general, 4IR is challenging despite the influence of confounding factors. There is therefore a need to address them and develop strategies aimed at thriving in Tanzania's growing new environment. Recent evidence has shown that starting with 4IR and influencing the way forward is central to shaping the future. The opportunities are as compelling as the challenges are daunting. So farmers must work together to turn these challenges into opportunities by preparing for their impact. 4IR generally brings challenges, even if it causes disruption. There is therefore a need to address them and develop strategies aimed at thriving in developing countries' growing new environment. Recent evidence has shown that starting with 4IR and influencing the way forward while looking ahead is key to shaping the future. The opportunities are as compelling as the challenges are daunting. So countries must work together to turn these challenges into opportunities by preparing for their impact.

Recommendations

Developing countries need to engage in all aspects of society because the challenges that people face are interlinked. In addition, developing countries must also develop a positive understanding of how it should shape the 4IR for present generations and posterity. Furthermore, developing countries should not neglect the restructuring of its socio-economic and political systems, as this awareness can lead it to take advantage of the opportunities available. The age of modern technology can also trigger a new cultural renaissance if it is shaped in such a way that East Africa becomes an integral part of something much larger than the region itself. This alignment has the potential to robotise humanity. Thus, 4IR can endanger families and identities, which could steer humanity towards a new path of consciousness informed by a shared sense of destiny. Some of the recommendations are listed below.

Policy Statements Requirements

Policy issues require a coordinated approach involving governments, private sector actors, civil society organisations and international development agencies. By adopting supportive policies and fostering an enabling environment for technology adoption, developing countries can harness the transformative potential of 4IR technologies to improve supply chain management, boost economic growth and improve livelihoods. Some areas that require policy statements are: Regulatory frameworks, digital infrastructure, skills development and education, public-private partnerships, financial incentives and support, interoperability and standards, data governance and security, inclusive innovation and access, to name a few.

Proper Education and Exposure of Citizens to the 4IR

Citizens should be made aware not only of the 4IR but also of its benefits and impact on their livelihoods. This would facilitate the adoption and use of better agricultural practises. Education in the 4IR is necessary to improve employability and economic prosperity, social inclusion and equity, and adaptability and resilience.

Proper Mobilisation of Capital

Proper identification of high impact areas and government support are critical. In this way, funds can be efficiently invested in mainstreaming 4IR aspects for better returns and profitability.

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Appendix 1: Stages of Industrial Revolutions

Revolution	Major driving force	Economic, social, political and structural changes
Agrarian Revolutions: Agriculture was the most important development for the rise of human civilisation. Farming and the domestication of animal species created food surpluses that enabled people to live in cities. The history of agriculture began thousands of years ago. After gathering wild grains at least 105,000 years ago, farmers began growing cereals about 11,500 years ago. Pigs, sheep and cattle were domesticated over 10,000 years ago. Subsequently, major changes in agriculture occurred between the early 19th and mid-20th centuries, when farming became industrialised and transformed from small-scale farms to large, commercial farms during the first and second industrial revolutions.	There were some developments such as the discovery of iron and domestication of animals that allowed the improvement of production.	The main source of energy in this period was either muscle or natural energy such as wind, fire and gravity. Improving production required more muscular energy. The domestication of animals also helped to improve the productive capacity of farmers in working the land, transporting produce and other tasks. These changes, which required more labour, also encouraged slavery. Ships used wind energy, while fire or sunlight were used to preserve food.
First industrial Revolution The first industrial revolution began in the 18th century and focused primarily on textile manufacturing and steam power. During this period, inventors created devices and machines that mechanised production. This transition involved switching from artisanal production methods to machines. Coal was the main source of energy.	At that time, the law of conservation of energy was stated, stating that energy can neither be created nor destroyed, but can only be converted from one form of energy to another. The world was no longer dependent on energy in its normal form, but was also converted from one form of energy to another.	The conversion of energy from one form to another no longer required the use of slaves to do the now automated work. There were also movements that saw slavery as inhumane. As a result, colonialism followed the slave trade, where producers of goods and services could sell their products. The introduction of power-driven machinery was an important development that proved to be a turning point. Most workers were unskilled, per capita income increased as did population, urbanisation, the impact on women and family life, the emergence of trade unions and others.

Second Industrial Revolution The second industrial revolution, also known as the technological revolution, was a period of rapid scientific discovery, standardisation, mass production and industrialisation from the late 19th to the early 20th century.	As the market flourished, so did the need for better production methods. Scientific management also emerged and grew, and models for production processes were introduced.	One of the most important developments was the emergence of management as a profession. As a result, several seminal articles on management appeared. In addition, the economy grew rapidly. There was notable growth of transport networks and organisational productivity. Higher industrial and agricultural production lowered the prices of almost all goods. In addition, crop failures in areas connected to large markets could no longer lead to famine because of the much more reliable transport infrastructure. Some of the ground-breaking achievements were in manufacturing. The American giant Ford Motor Company developed assembly lines that technically reduced the production costs of vehicles by increasing production speed.

Third Industrial Revolution The third industrial revolution, also known as the digital revolution, marked the transition from mechanical and analogue electronic technology to digital electronics, particularly through the introduction and proliferation of digital systems, which continue to evolve today.	When further automation became necessary, the advent of computers and other accompanying facilities of information and communication technologies made the work easier. For the first time, the concept of informatisation, i.e. the provision of information about underlying processes, became central to the global economy. The position of Chief Information Officer, reporting to the Chief Executive Officer, was now the rule rather than the exception.	The world saw the real growth of globalisation. At that time, the production of goods and services could take place anywhere on the globe and could be controlled from headquarters anywhere in the world. The basis for development was now measured by ICT indicators that were conventionally used, like how many people in a country have access to the internet. Some of the positive aspects of the third industrial revolution are networking, easier communication including social networking, smartphone technology, globalisation and outsourcing, improved productivity, demand for IT skilled labour and more.
4IR The success of the third industrial revolution made inevitable the 4IR, which conceptualises the rapid transformation of technologies, industries and social patterns and processes due to increasing interconnectivity and intelligent automation.	Key funding conditions for 4IR include digitalisation and integration of vertical and horizontal value chains, digitalisation of products and services, and digital business models and customer access.	During this revolution, a number of changes emerged, including privacy concerns, job losses due to automation, general reluctance of stakeholders to change, unclear evaluation of the success of investments and the skills required for change. On the other hand, 4IR is fuelling growth in the global economy, opening up new markets, boosting online mass production, leading to ubiquitous production and control, and improving worker safety by automating jobs in hazardous environments rather than relying on human labour.