

Significance of Artificial Intelligence and Data Sciences in Agriculture & Water Transformation in Sindh Dominance

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ABSTRACT

The research paper aims to emphasize on Artificial Intelligence and use of digitization in water & agriculture significance in Sindh. Water and Agriculture Management has always been a crucial debate in Sindh. Somehow, the relevance of water management is related to agriculture development and growth; therefore, signifies the role of data sciences, Hydro-Agro Informatics (HAI). The HAI combines hydrology, agronomy and also informatics that is beneficial for agriculture practices. AI in agriculture and water involves procedures- technique of scientific technology and its application. The real advancement in water management can be possible with AI. The paper also focuses on few challenges that HAI focuses on includes water scarcity, efficiency in agriculture and irrigation methods as well as utilizing advance technology. Data Collection and sensors is major focus for increasing efficiency in agriculture and irrigation. The usage of utilizing advance technology in weather station is also an important concept in HAI. The study concludes IoT (Internet of Things) can be game changer for agriculture and irrigation best practices.

Keywords: remote sensing; hydro-agro informatics, smart irrigation System; water conservation; IoT, crop rotation; diversification and adaptive decision support system.

Introduction

Sindh, is already trapped under many issues out of which water scarcity is most prominent. Sindh's economy relies heavily on irrigation. River Indus primarily plays a major role in providing water to distributaries at large scale. Sindh with adapting HAI advance techniques can

increase efficiency HAI works for integration of both water and agriculture transformation with use of advance technology (Vijendra Kumar, 2024). In this case, irrigation efficiency can solve Sindh's water scarcity issue. Also, data- driven decision-making system can help farmers, policy makers, engineers and state for further growth and development. This method can help in better decision making in terms of providing water to farmers to irrigate land; perhaps free flow of water. Moreover, with data-driven decision making and sustainable agricultural practices should be promoted in Sindh (Juan Cao, 2021).

Sindh is also facing extreme climatic conditions, heatwave, less rainfall and fluctuating weather temperature. In order to mitigate and control extreme climate conditions, policy makers suggest for conducting risk assessment at earlier stage. Advanced forecasting tools can also help agriculturalist to monitor risks associated with climate impact. This can also guide farmers to plan and understand prior risks therefore, smart climate adaptation can help in better decision making (L, 2023). There are many socio-economic benefits associated with HAI. Firstly, it can enhance overall productivity in terms of more crop per drop making Sindh food secure. Also, farmers can be benefitted with better knowledge perhaps farmers empowerment can also improve livelihood of rural women and children. Also, agriculture subsidies can also benefit smallholder farmers in long term. Sindh is already facing a lot of issues pertaining to changes in climate, water scarcity and ensuring sustainable green practices that are primarily main concerns of the government. HAI is concerned with data-driven techniques that require extensive work in satellite imaginary, geographical data collection and also remote observation. Besides agriculture productivity issues, Sindh is now facing problems in changing catastrophic flooding in the recent past years that has hampered agriculture as well as water production. Somehow, the agriculture and water data is not sufficient to meet the day to day challenges of water service delivery as well as agriculture production (Ahmed

A. Abdelhafez, 2020). The HAI program will fill the gap to provide nexus between water and agriculture productivity by managing water service delivery.

This HAI system can assess the existing framework along with ground water management system to enhance the overall water productivity. Also HAI is significant in terms of ensuring quality assurances of existing remote session data already been utilized in several projects. In this case, three barrages play an extensive role i.e. Guddu, Sukkur and Kotri barrage through 14 canals. In Sindh, ground water also plays supplementary role where water service delivery is comparatively less. The water quality is also poor and is saline or brackish (Mohd Javaid, 2022). Few of the water management challenges that are common also includes aging irrigation infrastructure, water delivery and pricing, deteriorating water quality and extreme climate conditions. Also, Sindh is facing socio-economic challenges such as extreme poverty, lack of awareness, lack of institutional set-up as well as other policy challenges. HAI can therefore make efficient use of water resources including monitoring of canal water. The HAI can also account for water distribution and efficient use of water (Ghalib Muhammad Shahriar Himel, 2023) The integrated Water Resource Management (IWRM) and Participatory Water Management also focuses on making strong bodies with farmers organization and aligning it with Area Water Board (AWB).

Efficient water management also accounts for smart irrigation system and practices by involving data that can predict weather forecast that is detrimental for water availability and delivery for effective farming. Most of the data shows that better water allocation can be beneficial and HAI can help farmers to provide water if required at certain level. This can also increase crop productivity. Farmers in long term can get used to decision based on best time for plantation, pest content as well as better farming (Kuntal Das, 2010). Advance HAI programs can also help in yield prediction models, hence allowing farmers to predict soil efficiency and soil

moisture. HAI tools if used efficiently can also benefit farmers in long term i.e. the farmers can practice crop rotation at real point in time. Soil quality and health are also important in case of maintaining agriculture productivity. Therefore, sustainable agriculture practices are one of the main objectives of HAI tools and models. Perhaps the role of climate resilience can also play a major role such as in controlling the environment through efficiency of water through better agricultural practices (Tawssef Ayoub Shaikh, 2022). Sindh can reduce the issues of water logging, water salinity and also source of the major issues involving soil erosion.

The hazardous environmental impacts can somehow be continued with efficient use of water resources and protecting crops and livestock. The HAI advance tools and practices thus involves environmental safety technology that is beneficial for agriculture and environment. In 2018, UN FAO also presented in their report Presented major concerns over catastrophe in controlling food insecurity particularly in least developed countries most of the technological advancement in AI can definitely help in agriculture and food productivity and also addressing major challenges of increasing global population that has affected the overall equilibrium of demand and supply (Raj Kumar, 2021). The AI application along with HAI can help farmers in empowering others and to contribute in performing and carrying out tasks that are time taking. Machine learning, IoT can also optimize the level of efficiency both in food and water productivity. These applications can also help in maintaining growth levels, forecasting weather and climatic changes. The stakeholders and policy makers can also focus on effective agricultural practices (Margaret A. Goralski, 2022).

Literature Review

The few data collection methods that can help in data collection as well as sensors include the soil moisture sensors can help in measuring the overall soil level for irrigation that can further help in efficiency and optimizing irrigation (Abdellatif Soussi, 2024). Also, the

weather stations are great help in terms of predicting weather; also using satellite imagery for analyzing crop health and also the quality of soil. Moreover, the HAI data analysis will include some of the major tools that are predictive analytics (S. V. S. Ramakrishnam Raju, 2022). Through Predictive Analytics one can analyze the data and also estimate the general water needs and also analyzing historical data. Hence, this can further be used for irrigation scheduling. Also, Drip & Precision Irrigation can also be used in water thrift cropping utilizing minimum water with maximum yield. AI Technology can also assist in water control (Olutobi Adeyemi, 2017). For sustainability and efficient water use, sustainability practice can help in making strategies for applying practice and focus ultimately on using less water.

The sustainable farming can be another technique if applied can promote efficient use of water. Most of the literature showed that crop rotation can further help in better production. Crop rotation and diversification can be beneficial in long term for sustainable farming. Geographic Information System (GIS) is another method to examine and mapping of water resources. GIS can also benefit and assist in investigating spatial data pertaining to irrigation (Yacob Abrehe Zereyesus, 2021). Irrigation management can also include adopting Smart Irrigation System such as adopting automation structure to regulate water delivery and on time. Based on real time data this data can be analyzed further for decision making process. The Decision Support System (DSS) is being adopted by various sources for in order to help farmers in decision making process for resource allocation, sustainable farming and planting. The initial HAI program in Sindh can successfully help in sustainable growth and agriculture practices (Brian E Mennecke, 1996). Most of the literature review shows that HAI program can also be beneficial for Sindh's water productivity and sustainable growth levels.

Challenges in adopting HAI Model

One of the biggest challenges in adopting HAI is lack of infrastructure in Sindh as the province lacks institutional development due to lack of infrastructure. Also, internet connectivity is also very low and some areas are affected by no connectivity at all. The lack of resources/tools in data collection system has also overall affected. Another challenge with adopting HAI model is farmers/practitioners lack necessary skills to counter and manage data. The IoT is also now active with the aims to manage data efficiently. The extensive training in this program can be beneficial for work force in order to account overall agriculture produce. However, HAI sometimes also involves usage of advance technology, therefore, training and capacity building is necessary for all professionals involving in agriculture sector. The farmers should be well equipped in terms of usage of technology and managing data efficiently.

In case of sensitive data collection, there is a need to handle data efficiently with privacy and security. Also, farmers can be trained by agricultural professionals to handle sensitive data and information regarding forecasting, crop management, crop rotation as well as water delivery. There are various research tools available for advance agro-informatics that can involve various tools that can be beneficial for food security, agriculture production and consumption, carbon accounting as well as policy making.

The information and communication technology (ICT) tools are advanced in terms of monitoring and also improvement in artificial intelligence. The farming practices should also involve GPS machinery to control the farming practices. The role of agro-informatics in this case is essential such that there should be application of models. The sensors are also embedded in the case to support satellite imagery and control the overall agricultural growth and production. The weather situation can counter the weather information. The weather control department can also counter the forecast.

Key Application of HAI Model

The HAI model uses field level management that will utilize system of application and usage of model. GPIS system that can look after crops and agriculture produce. This approach can utilize to look after agriculture produce and can involve reducing waste and also crop consumption pattern. The crop health can also be improved with sufficient content such as water conservation and practices. Agriculture practitioners can further be trained to manage agriculture and crop rotation. Through crop rotation, the farmers can benefit the agriculture production and consumption.

It is also important to manage the resources efficiently and timely. There is also a need to protect the ecosystem and its management. There is overall agriculture supply chain that is involved while looking at the entire agricultural model. Also, this will involve other stakeholders as well in the agriculture supply of farmers, water distributors, forecasting and also the agriculture production. Also, for sustainability and efficiency, there is a need of streamline the HAI practices throughout Sindh by tooling at its benefits. Another benefit we can get through HAI is better resource management. Farmers can use sustainable farming along with resources management to optimize the overall produce. AI in agriculture can transform crop production, crop rotation and can also balance the demand and supply of crops (Neethirajan, 2020)

AI in agriculture and water productivity

Discussion

The future trends of hydro informatics require adoption of AI and machine learning. Farmers need to switch from traditional means to advance predictive tools that can be helpful in managing water. Also, IoT can built up better connectivity in terms of monitoring & evaluation as well as controlling modern devices and tools under farming. Sindh is also facing some of the challenges in focusing on implementing policies already drafted such as Sindh Water Policy and Sindh Agriculture Policy. Both the

policies are supporting in sustainable best practices in implementing successful modeling in Sindh. The biggest challenge is therefore accounting for policies that can help in agriculture management and production.

Modern farming practices are mostly driven by smart technologies and practices to transform overall agriculture process. The world's focus is now on adapting smart sensors, IoT and AI to optimize crop rotation and management. The current revolution in water and agriculture sector is due to GIS & GPS. This has also improved the productivity and also increase crop yield. Globally, most of the water is utilized in irrigation use. Hydro-informatics exists and has been applied by many agriculture and water experts. The application includes hydraulics, environmental sciences, management and operations. The modern system of development in water sector encounters use of HAI, whereas, the traditional means of agriculture resulted in low water efficiency as well as low productivity.

The world is now focusing on food security in order to control environmental factors that can promote effective monitoring through water control and water use. There has been rapid change in water serving and conservation in Sindh in past many years. There is also need for appropriate irrigation system of management that can promote smart agriculture application. The scope of HAI can be seen reaching towards various GIS based programs that includes data facilities, water overflow assessment, flow and irrigation monitoring as well as ground water monitoring and control. The new tools in monitoring water service delivery can also increase the overall scope of hydro Extra Informatics Here, the role of science and technology plays a vital role in fulfilling the overall need and criteria of water governance. The government while introducing HAI mechanisms can also work on research and development of irrigation and water resource management by expanding the overall water resources. State can also expand its scope for development at various paradigms of research and can further focus on modeling system, Decision Support System (DSS), surveying technology and Real Time data surveying.

Furthermore, with the introduction of artificial intelligence most of the water related data can be stored using big data or cloud that can help in digital storage. Also, there are now changes with climate that can be a major source for transformation in water and agriculture practices. The enhanced practices can therefore come when farmers can adopt community water resources management program to overcome global food security crisis. The most common concerns in the global world are resulted due to increasing population and migration crisis both forced and voluntarily. Globally, the increase in migration and population has created an alarming situation and somehow it has also impacted the demand and supply of water and agriculture. In this situation the state should take measures in sustainable water resource management water resources and its efficient management is often influenced by factors such as politics economic social as well as environmental concerns.

Moreover, the long term challenges of agriculture and water productivity can be solved only with AI. AI application can help farmers predict the climatic changes and in extreme conditions it can be helpful. The monitoring patterns can smoothly be monitored using these applications that can help in maintaining efficiency and long term planning.

Conclusion

DSS can help farmer community in general in order to control water waste as well as optimizing water use and reducing water cost. HAI can be beneficial in increasing crop yield and also enhance water efficiency and control. Most of the farmers in Sindh often gets in trouble in not receiving water on time (David James Molden, 2003). Providing right amount of water through hydro informatics can promote in environmentally friendly agrobusiness pertaining to select best practices out of it. Better sustainability can also conserve water resources and contribute to effective water management. There are always challenges associated with HAI i.e. managing large volumes of data can be problematic. At times,

farmers cannot get accurate data in presence of bulk data. Also, farmers can also show reluctance or fear in adopting new technology as they are used to traditional methods of irrigation. Even if they adopt new technology farmers may get benefit in long run for initial investment; having no benefits in short run (Andrea Momblanch, 2018).

The future of HAI is concerned in filling the gap between agriculture and water users. The accessibility and availability of more water resources can further fill in the gap. Also, the government can help in disseminate information on water production as well as conservation. It is also recommended that Sindh can work on massive digital mechanism in terms of decision support services both for agriculture and water component. Sindh government can also take steps in making departments responsible for their own actions in terms of making overall HAI system more reliable.

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