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CLIMATE RESILIENT STRATEGIES FOR SUSTAINABLE WATER RESOURCE MANAGEMENT IN AGRICULTURE: A REVIEW

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ABSTRACT

The most common impact of climate change due to global warming is reduced agricultural output, food security, seawater level rise, glacier melting, biodiversity loss and lack of water resources. A decline in agricultural output and deterioration of water quality have been noted over time as a result of climatic abnormalities. Climate has a significant impact on crop production. It is impacted by annual climate fluctuations, shocks during various growth stages, long-term trends in average rainfall and temperature, and extreme weather events. Anticipated water scarcity, coupled with the difficulties posed by climate change and global warming, is making the management of water resources in both rain-fed and irrigated agriculture more difficult globally. Water resource play an important role in the agriculture sector right from the germination of the seeds till the harvest of the crop and even in the post-harvest process. By 2025, the world's water demand is predicted to have increased from 40 billion cubic meters (bcm) at present to approximately 220 bcm. Water shortage has drastic effect on the growth and development of plants reducing the quality and yield of produce. Addressing this problem with crop management practices is very crucial for saving water resources for future generation.

Key words : Climate change, Global warming, Biodiversity, Water shortage, Crop management.

Introduction

Man-made and natural activities both contribute to climate change (Karimi, 2012). The majority of the global warming that has been seen in the past 50 years has been primarily ascribed to human activity, including changes in land use and excessive use of fossil fuels (Ravindranath and Sathaye, 2003; Karimi *et al.*, 2018). With the reference value of 1986–2005, the sea level has already risen by 19 cm due to glacier melting, and it will rise by another 24–30 cm in 2065 and 40–63 cm in 2100 (IPCC, 2018). The water demand of crops and agricultural output are impacted by ongoing changes in weather patterns. India has merely 4% of the world's water resources which is depleting at a rapid rate due to climate change (Kumari and Singh, 2016). Majority of water resources accounting about 98% available on this planet is found to be salty and unfit for consumption. Rest 2% is available as fresh water reserves, out of which 1% is in the frozen ice form and only 1% is available for industrial, domestic and agricultural purpose. Due to rapid deforestation, urbanization, industrialization and population explosion resulting in depletion of ground water levels and climate change showing its adverse effect worldwide out of which major impact is seen in shortage of water in many cities in India and the world. Climate change impact is clearly visible in terms of prolonged drought period, flood, rise in temperature resulting in melting of glaciers and rise in the sea level creating shortage of freshwater to sustain the population.

According to estimates made by the Ministry of Water Resources, Government of India (1999), the nation will require 1100 billion cubic meters (BCM) of water by the year 2025, of which 900 BCM will be required for irrigation resulting in harsh competition between different sectors for water (Kumar *et al.*, 2005). Water resources are depleting at a steady rate so there is an urgent need to address this global issue and adopt water saving efficient techniques keeping in mind for future generation. Agriculture sector is the largest user of water in the world and agricultural crops require water at each and every phase of plant cycle right from germination till harvest and further in post-harvest management and processing. Water shortage results in crucial phases of plant cycle results in poor development and growth of plants, which results in huge reduction in yield and sometimes wilting and ultimate dying of plant. Every other sector is directly or indirectly depended on agriculture. Therefore, if agriculture fails due to water scarcity and climate change, there will be a disbalance in all other sector affecting economic development of the country.

Climate change has a huge impact on the crop growth and production affecting infinite number of farmers worldwide. It causes natural calamities like drought, flood, storms, heavy or scanty rainfall causing huge loss in the crop production. To address this problem, one should adopt water saving irrigation method like drip irrigation, sprinkler irrigation and moisture conservation practices like mulching and use of hydrogel in farming for saving water resources for the future generations. Developing crops resistant to climate change, managing irrigation water, implementing a climate-smart agriculture strategy, and fostering indigenous knowledge can all contribute to food security by raising agricultural yield. The scientific analyses of the climatic parameters needed for the management of sustainable agriculture can be provided to farmers through technical assistance. Software applications, nutrient and water management techniques, temperature measuring devices, soil health analysis tools, and more are examples of these technologies. The risks of climate change on agriculture and water resources can be reduced more effectively through the combined efforts of all stakeholders, including farmers, local society, academia, scientists, policy makers, NGOs, etc.

Climate Resilient Agriculture

Climate resilient agriculture (CRA) is a sustainable strategy that uses various adaptation and mitigation techniques to transform and reorient agricultural systems to support food security in the face of the new climate reality. Agricultural systems are particularly vulnerable to climate change due to their sensitivity to variations in various threats such as temperature, precipitation, and the frequency of natural events and disasters like droughts and floods. As a result, on average, the extreme weather patterns can have an impact on farm incomes of between 15% and 18% (Debangshi, 2021). Since the effects of climate change are so common, CRA should always be ready with the best mitigating and adaptive measures available. Through, various village-level awareness programs, climate resilient agriculture should not only be implemented but also sustained or maintained over time. The government contributes significantly through various programs and subsidies. Now, 100 vulnerable districts—identified based on their exposure to recurrent climate vulnerability—are participating in technology demonstrations funded by the National Initiative on Climate Resilient Agriculture. The National Mission on Sustainable Agriculture (NMSA), other National Missions, and ongoing government programs like Rashtriya Krishi Vikas Yojana (RKVY), Mahatma Gandhi National Rural Employment Guarantee Programme (MGNREGP) and National Food Security Mission (NFSM) aim to mainstream some of the effective practices and technologies that promote resilience to climate risk.

Effect of climate change on crop production and food security

As the world's population has grown exponentially, agricultural lands have become scarcer, urbanization has increased and land use has change (Rotolo *et al.*, 2015), food security has grown to be a global concern (McKenzie and Williams, 2015). The agriculture sector in developing nations has been identified as one of the most vulnerable to climate change, per the reports of the FAO and IPCCs (Melkonyan and Asadoorian, 2014; Lu *et al.*, 2019; Manuamorn *et al.*, 2020). With a population of about 9.1 billion, global food production needs to rise by 50–70% by 2050 (McIntyre *et al.*, 2009) to maintain current dietary patterns. This will further increase greenhouse gas emissions from agriculture by about 30% (Tubiello *et al.*, 2014), particularly in Asian and African nations where a large portion of the population depends on agriculture and related livelihoods (Sapkota *et al.*, 2019).

There is a drastic effect of climate change observed in the agriculture sector due to numerous factors like industrialization, deforestation, utilization of fossil fuels (*i.e.*, oil, gas, and coal) for transportation, urbanization leading to modern lifestyle changes and use of refrigerator emitting harmful gases disturbing the ecological balance. The growth and development of crop primarily depends on climate, soil and water resources. Weather condition plays a pivotal role in the success/failure of crop. All stages of crops are affected by climatic factors right from tillage to storage, highlighting the need to have proper knowledge and understanding to farmers about the interaction of climatic factors with crops (Sadras *et al.*, 2016). Manipulation of weather pose major challenges and are not cost effective to the small growers, therefore adopting suitable agricultural practices and implementing proper cropping patterns is found to be beneficial in reducing the negative impact of weather conditions and simultaneously improving the crop yield.

Climate change impact on the water resources

Since groundwater provides one-third of the water needs of the world's population—roughly 85% of rural population and 50% in urban population—it is a prime source of drinking water, a valuable natural resource, and essential to the survival of all living things (Kumar and Shah, 2006; Aslam *et al*, 2018). Climate change is a major contributor to the pressure on groundwater's natural recharge in terms of time, magnitude, and chemical contamination, among other factors (Hiscock *et al*, 2011; Taylor *et al*, 2013). Climate change causes deterioration in water quality, which will undoubtedly impact water availability because low-quality water is unfit for domestic and drinking use (Srivastav *et al*, 2021). Extreme weather events like tropical storms, droughts, flooding, and rising temperatures brought on by climate change have also put a great deal of strain on water resources and availability (Allen and Ingram, 2002; Hagemann *et al*, 2013; Schewe *et al*, 2014; Cui *et al*, 2019). Additionally, it has put surface water reservoirs water supply at risk, particularly during the irrigation season when crop growth demands are higher (Vano *et al*, 2010; Malek *et al*, 2018; Michalak, 2020). The main industry using freshwater worldwide (for irrigation purposes only) is agriculture, which uses an estimated 900–1700 × 10^9 cumec/year (Chaturvedi *et al*, 2013). Due to drastic climate change, this amount is expected to rise by 14.7% until 2095.

In addition to hydrological disruptions, climate change may also control the availability of nutrients in agricultural fields (Howarth *et al*., 2006). High evaporation rate due to increase in atmospheric temperature due to climate change have resulted in increased precipitation. The temporal and spatial distribution of runoff, soil moisture, groundwater, reserves and the frequency of drought and flood can all be impacted by changes in the precipitation pattern. Though the effects of seasonal temperature variations are felt worldwide, developing nations with agrarian economies, such as India, are probably going to be affected more severely.

Rapid growth of population and increase in industrialization results in more demand of freshwater is a matter of concern in the climate change scenario. People are facing acute shortage of water with the change in weather pattern. The rise in atmospheric temperature due to climate change is resulting in rapid melting of glaciers at a steady rate resulting in increase of flood risk affecting the population mostly during the monsoon and alternatively water crisis during the dry season. The impact of climate change on surface water resources is largely driven by temperature and rainfall in the river basins (Pathak *et al*., 2014).

The intensity and frequency of heavy rainfall events, such as floods, mudslides, typhoons, and cyclones, have been predicted to increase (IPCC, 2008). Low rainfall events are likely to cause a decrease in river flows, which will both severely harm the quality of the water. Elevated temperatures and fluctuations in precipitation are anticipated to hasten the retreat and melting of glaciers, impacting river flows and subsequently farming. The global hydrological cycle will be impacted by rising sea levels, leading to an increase in precipitation overall, a reduction in the number of rainy days, more rainfall in shorter amounts of time, and an initial increase in runoff from glacial melt. Consequently, there would be a rise in flood events (especially flash floods), landslide incidents in hilly areas, drought-like conditions, and an increase in runoff (but a decrease in groundwater recharge (Kumar *et al*., 2005).

Techniques for adaptation to climate change

Climate change can be mitigated through the implementation of programs such as weather-based agro-advisories, crop and variety selection, efficient cropping systems, water harvesting for resource conservation, customized farm machinery hiring, and emergency planning, among others.

Agro-advisories based on weather : Weather parameters like rainfall, relative humidity, temperature, wind speed etc are recorded at weather stations at KVK and through mini-weather observatories established in village level to bring awareness and improve literacy about weather to the farmers. Farmers get proper information about the weather in the form of wallpaper placed at public places like Schools or Panchayat buildings. With improvement and advancement in technology, mobile phones are made in use to spread information to the farmer community about the short coming weather condition. This in turn helps the farmers to plan and act accordingly, reducing the ill effect of weather at the farm level.

Smart Crop and Variety selection : The best option for adaptation is to choose a crop variety that is climate-smart; crops with multiple sowing windows can be sown on a wide range of dates. Certain weather events, such as heat waves or cold snaps, floods, cyclones, frost and hailstorms, lessen a given zone's potential climatic yield. Thus, we must choose a crop that is appropriate for this specific area based on long-term research data and weather forecasts. A short-duration summer legume, such as moong bean, can be introduced as a break crop or catch crop in a rice-wheat cropping system to maintain soil quality, add organic matter, and lower nitrogen dioxide emissions from the field because moong bean can use up any leftover nitrogen after wheat is harvested. Relocating crops to alternative areas can occasionally be a great way to combat climate change. For instance, crop quality is reduced by rising temperatures in crops such as basmati rice, tea, and coffee. Therefore, it is important to allocate crops to alternative areas that meet quality standards.

Effective cropping system based on climate : An efficient cropping system is one that is location-specific, able to minimize pest outbreaks, control weeds, and meet consumer preferences while also meeting soil health and market demands. Relay cropping, intercropping and mixed cropping lessen climate vulnerability. If there are unfavourable conditions, farmers can still harvest at least one crop. Pigeonpea performed much better when used as an intercrop or base crop, especially in cropping systems based on sorghum, cotton, and pearl millet (AICPRDA, 2013). Adding legumes to the cropping system increases its sustainability by adding biological nitrogen and soil cover. One widely used tactic in rainfed agriculture is the cultivation of a legume, typically following the main cereal crop.

Water harvesting : India, which has a land area of 3.29 million km^2, is home to over 18% of the world's population, but its freshwater resources only make up 4.2%, according to the World Bank. The effects of climate change will be felt in agriculture and water resources. A rise in temperature will cause crops and natural vegetation to require more water for evapotranspiration, which will speed up the depletion of soil moisture. A 1°C increase is predicted to result in a 2% increase in crop water requirements. Sea level is greatly impacted by climate change, which may also have an effect on the salinity of groundwater and surface water in coastal regions. The availability of regional water supplies and hydrology may be significantly impacted by the rising CO_2 concentration, warmer atmosphere and more intense precipitation. While more precipitation causes runoff, a rise in temperature may increase the need for evapotranspiration. Thus, the resource-saving adaptation program in water management will benefit greatly from water harvesting. A rain harvesting system (water tank, dug well, percolation tank, farm pond) is used to catch and collect rainwater during the rainy season in dry and dryland farming areas. The rain harvesting system lowers the amount of electricity required to pump in lift irrigation. Then, when there is a lack of clean water during the dry season, people can use and consume this water. Rainwater harvesting may be a more effective way for developing nations like India to adapt to climate change (Pandey *et al.*, 2003). Rainwater harvesting is an alternate method of supplying drinking water to arid regions (Musayev *et al.*, 2018). Similarly, rooftop systems, water spreaders, interrow harvesting, runoff farming, micro-catchments (roughly 1000 sq. m), small farm reservoirs (1000 to 500,000 cu. m), Crop water stress may be lessened by on-farm techniques such as contour ridges, semi-circular and trapezoidal bunds, small pits, runoff strips, small runoff basins, macro-catchments, and flood water systems. The growers can occasionally receive a respectable yield from 1-2 additional irrigations from these water harvesting structures.

Balanced fertilization : The right supply of all nutrients—macros and micros—during a crop's growth is known as balanced fertilization and it promotes the best possible crop growth, yield and quality. "Balanced Fertilization" refers to the application of fertilizer in the ideal ratio and sufficient amounts. Protein synthesis requires nitrogen, and this plant needs the right amount of energy and enzymes, which is provided by phosphorus and potassium provide. Therefore, balanced application minimizes the loss of nutrients from the system. The best plant growth is achieved with balanced fertilization, which also has a very high rate of nutrient utilization and fewer negative environmental effects.

Hiring of farm machinaries : Since land fragmentation is a major issue at the village level, community nurseries and the rental of farm equipment by the community lessen the strain on the environment from fewer cultivation practices. Each village has a community-managed custom hiring center set up to provide access to farm equipment for prompt planting and sowing. This is a crucial intervention to deal with climate variability, such as delayed monsoons and insufficient rains that require crop replanting.

Contingency planning : The term "contingency crop planning for reverent rainfall" describes the process of organizing a different crop and cultivator to best suit the soil and rainfall resources available at a specific site (Reddy, 2019). The best practices for achieving maximum yield in rain-fed areas are generally to start cropping as soon as the monsoon arrives. Replanting, thinning the crop, eliminating the substitute crop, creating a dead furrow, applying 2% urea, KNO_3, or DAP, and cultivating storm-resistant crops (like pineapple, ginger, etc.) are some effective climate change mitigation techniques.

Minimizing food waste and losses : Approximately one-third of the world's food supply is lost or wasted annually, according to estimates made by the FAO in 2011. We are usually focused on finding ways to produce more food, but if we can decrease food losses, we can use resources more efficiently and relieve the strain that food production places on farmers and the food production sectors. One of the best ways to decrease food waste at home is to freeze extra garden vegetables, plan meals in advance, and rotate perishable items in the refrigerator and cabinets. Process or dehydrate excess or spoiled produce, meats, and fruit. At the very least, composting kitchen waste will improve the health of the soil.

Improved crop management practices : Many opportunities exist for promoting sustainability in crop production on well-managed crop land. The predominant way that rice is grown in India is as a transplant, which has negative effects on groundwater supplies in addition to emotional issues. The process of intermittent irrigation lowers the total carbon flux by 40% while increasing the N_20-N emission by 6% because of more water-filled pore space. Low bulk density at the surface also inhibits the diffusion of O_2 into the soil. Ninety percent of the CH_4 in rice is absorbed by the paerenchyma tissue during the tillering to reproductive stage, when rice emission of CH_4 peaks. In order to decrease the amount of CH_4 produced in rice fields, we need a resilient system, such as alternate wetting and drying (AWD) and direct seeded rice (DSR). The reduction of CH_4 emissions is approximately 80-90% for DSR and 30-40% for AWD. Microorganisms can significantly contribute to a variety of climate change adaptations, including preserving genetic variability, boosting water use efficiency and creating resistance to extreme weather events (such as drought, flooding, cold, salt concentrations, metallic toxicity, heat strokes, etc (Grover *et al.*, 2011). The balance of an ecosystem also depends on crop cover because it prevents soil erosion, improves water availability, inhibits weed growth, helps manage nutrients in the soil etc (Meyer *et al.*, 2019). Numerous studies that highlight the advantages of cover crops have been conducted (Snapp *et al.*, 2005; Tonitto *et al.*, 2006).

Recarbonization of soils : The management of soil organic carbon is essential to building soil resilience against climate change. Infiltration, fertility, nutrient cycling, wind and water erosion reduction, compaction reduction, improved water quality and overall environmental quality can all be improved by increasing soil carbon storage. Increasing the sequestration of carbon through the use of best management practices (BMPs), such as agroforestry, legume-based crop rotation, permanent plant cover in the soil to eliminate the fallow period, residue management, etc. A tonne of burned rice residue emits 1515 kg CO_2, 0.4 kg SO_2, 2.5 kg CH4, 92 kg CO, 3.83 kg NOX and nonmethane volatile organic compounds (Andreae and Merlet, 2001) which can exacerbate the effects of climate change. Retaining crop residue without burning it can help the soil absorb some carbon. The ratio of C to N is crucial for the retention of CO_2 in the soil, and legumes are a significant source of N that helps regulate C-sequestration. Agroforestry, which typically involves carbon capture and the long-term storage of atmospheric carbon dioxide, is an excellent choice for recarbonization through global carbon sequestration. The amount of carbon stored in soil in an agroforestry system varies from 30 to 300 mg C/ha up to 1m (Nair *et al*., 2010).

Zero tillage/ No- tillage : The balance of greenhouse gases (GHGs) and the physical characteristics of soil are significantly impacted by soil tillage techniques. Farmers can save money on labor and fuel, lessen soil erosion, and protect valuable nutrients by not tilling their fields. Additionally, no-till farming promotes the build-up of soil organic carbon, which helps to sequester carbon dioxide from the atmosphere. Research has shown that conventional tillage systems have a significantly higher net global warming potential than zero tillage systems, ranging from 6 to 31% (Mangalassery *et al.*, 2014).

Integrated farming system (IFS) : Using sustainable farm resources and cultivating a variety of crops on the same land, integrated farming has the potential to greatly increase farmers' resilience to climate change. IFS frequently carries a lower risk because it manages the farm more effectively, reducing output dependence. IFS is environmentally sound and profited from enterprise synergies. It has been discovered that judicious use of farm resources in conjunction with appropriate recycling of byproducts, crop residue, weeds, and other farm waste can reduce chemical load in the form of inorganic fertiliser by 36% (Gangwar *et al.*, 2014).

National programmes to mitigate climate change : The National Mission of Sustainable Agriculture was one of the eight missions under the National Action Plan on Climate Change (NAPCC) that was put into effect in 2010 with the goal of encouraging the efficient use of already available resources. In order to address the problems with water resources and offer a long-term solution that envisions Per Drop More Crop by encouraging micro/drip irrigation for the maximum amount of water conservation, the Pradhan Mantri Krishi

Sinchayee Yojana (PMKSY) was introduced in 2015. In order to mitigate the negative effects of climate change, the Government of India (GOI) launched the GREEN INDIA Mission in 2014 under the auspices of the Non-Agricultural Policy and Consulting Committee (NAPCC). The mission's main goal is to protect, restore, and enhance India's declining forest covers. Neem Coated Urea was also added in order to reduce the overabundance of urea fertilizers, safeguarding the health of the soil and providing nitrogen for plants.

Water management and conservation strategies in climate change scenario

The following measures should be adapted to cope up with the climate change:

- Schedule of irrigation should be based on modern GIS Modelling and Simulation models should be in practise to calculate the demand of water based on specific crops.
- Efficient and judicious use of water should be practiced at farm level based upon water requirement of crop. Crop management practices like mulching, crop should be chosen according to water availability and prevailing agro-climatic condition, suitable irrigation method like drip or sprinkler irrigation depending upon crop requirement should be adopted to minimize the water loss. Micro-irrigation makes sure that the ideal ratio of water and nutrients is present in the root zone, meeting the crop's total water and nutrient requirements. It also helps with nitrate levels, soil salinity, preventing evaporation, and water conservation (Suryavanshi *et al*., 2015). Additionally, it has been shown to benefit farming even in situations where there is less water and fertigation available because it balances the needs for nutrients and water, lowering the need for extra fertilizers and the possibility of groundwater contamination from leachate production (Surendran *et al*., 2016; Lamm, 2016). In areas with limited water resources, hydrogels are a viable and cost-effective solution for boosting agricultural output and environmental sustainability.
- Extension activities making farmers aware about the government schemes and subsidies on irrigation system (drip or sprinkler irrigation), water conservation methods and recharge devices.
- Rainwater harvesting should be brought in practiced and rainwater can be collected in tanks, ponds and other structure. Along with it soil moisture conservation should be practiced to minimize the water loss of the crops.
- Minimization of water wastage at domestic and industrial level should be done. Timely maintenance of water leakage, recycling and reuse of water in the household chores like coolers and washing machine, water saving devices
- Leakage reduction, use of co-operative water saving devices, regulation and restriction reuse, and cultivation of appropriate less water requiring crops and plantations in kitchen garden can help in conservation or saving water. Recycling and reuse of water can mainly be applicable in the cooling systems, washing systems and material transport. The industrial waste water can be treated and used in the cultivation of trees.
- Modern pressurized irrigation system like drip and sprinkler have proved to be advantageous in minimizing wastage of water, improving crop yield over other irrigation methods like surface irrigation. Such modern irrigation system applies water directly to the root zone of the plants thereby saving water loss. Crop yield is significantly improved under such irrigation system. Some of the advantage of pressurized irrigation system includes better soil health and reduced labour cost.
- Application of modern information technology with advanced GIS (Geographical Information System), remote sensing and simulation tools have opened new arena for efficient management of available water resources. Since these tools will allow system managers to make decisions quickly, they should be incorporated into scientific management of irrigation networks, water distribution, crop planning, and related operational activities. Effective management of water resources and risk assessment regarding the hydrological cycle of water are facilitated by the use of remote sensing and geographic information systems (GIS). Understanding the appropriate timing and volume of water to use for irrigation is crucial in agriculture. Wireless sensors can be affixed to crops in the ground to track soil moisture content and humidity levels. They can also be used to automatically open irrigation system valves when necessary to supply the necessary amount of water to maintain plant health.
- Saline water though readily available is rarely used in agriculture because it inhibits plant growth and yield. Recently, crop varieties resistant to salt have also been developed.

- For paddy fields, contour farming is used in lowland and hilly regions. The effectiveness of contour-based systems for preserving water and soil is acknowledged by farmers.
- Drought-resistant plantations, or plantings of plants that require less water, should be implemented as a first step toward conserving water and propagating native plant species.
- Another way to greatly increase the benefits is to transfer water from surplus basins by building storage at suitable locations and connecting different systems.
- Ridge and furrow method can be used in In-situ management of water at farm level. This method of cultivation drains out the excess water which is effectively utilized for recharging ground water simultaneously saving the crop from water logging problem.

Conclusion

The main channel via which people, ecosystems and economies will be impacted by climate change is water. Therefore, managing water resources should be the first priority when it comes to climate change adaptation. Water is vital to sustain life, growth, survival and economic activities globally. Agricultural sector plays a major role in food security and GDP contribution of a country. With limited water resources and drastic effect of climate change in agricultural crops, it is the need of the hour to effectively manage and utilize the water resources for sustainable agricultural crop production. Irrigation system technological advancements have increased crop yield and have the potential to support agriculture's ability to evolve to the effects of climate change. The efficiency of crop water use has increased with the use of modern irrigation systems, particularly sprinkler and drip irrigation. Even in soils with limited water-holding capacity, crops could be grown with the aid of these technologies. River levels can be tracked and forecast, and new freshwater sources can be found, by utilizing technologies like satellite remote sensing, semantic sensor web, and geographic information system (GIS) to gather real-time data on water consumption (Kumar *et al.*, 2021). People at the individual level have to act as a global community and use water wisely. The key to intelligence is conservation and not lavishness, so that future generations can still experience the wonderful sensation and touch of water.

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