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# Evaluating the Impact of Digital Tools on Empowering Marginalized Communities to Combat Environmental Injustices

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***Abstract***

*The proliferation of monitoring technologies, big data, enhanced analytical capabilities, and other advancements presents an opportunity, although with certain considerations, for technological progress to address enduring environmental justice issues. The interactions between the digital world and the environment present a diverse range of interdependencies. These range from utilizing technology to map, monitor, and predict environmental issues and impacts, to proposing, simulating, and implementing strategies to mitigate negative impacts on the environment. Digital technologies have the ability to collect, process, and analyze vast amounts of data. This enables them to identify problems and potential solutions, as well as predict future developments. Additionally, these technologies can streamline processes, reducing the need for resources such as natural resources, human efforts, and finances. Several digital technologies have been extensively adopted in the field of environmental protection. Communities that are marginalized face challenges that are a direct result of their marginalization. These challenges include exclusion, invisibility, misrepresentation, and hate speech. These challenges are not just experienced offline, but also increasingly online as a result of changes in digital technology. The term "digital marginalization" is typically used to refer to individuals who do not possess or make use of the internet, individuals who do not have access to a fast and dependable*

*internet connection (for example, individuals who reside in rural areas), and individuals who do not possess the skills necessary to use the internet or who do not have access to the resources necessary to develop those skills. However, the concept of digital marginalization encompasses more than just those individuals who have restricted access to the internet and inadequate digital abilities, it also has a social dimension. To put it another way, digital marginalization also refers to the reproduction of marginality in digital arenas like social media. This study seeks to investigate the convergence of technology and environmental justice, with a specific focus on how digital tools and platforms can empower marginalized communities. This study aims to investigate the effectiveness of digital literacy and education in raising environmental awareness. It also explores how digital innovations can improve environmental monitoring, enforcement, and accountability mechanisms. Through a thorough analysis of existing literature, this study aims to identify any areas that may be lacking and provide valuable recommendations for enhancing policy and implementation. In order to achieve the intended objective, the current study will gather data from a range of reputable secondary sources, such as books, journals, articles, and reports that are relevant to the topic. The review's findings provide insight into the complex connection between technology and environmental justice, as well as the role of environmental education and awareness in fostering environmental accountability. This study, therefore, adds to the existing body of literature by providing a comprehensive analysis of the role that digital tools, digital literacy, and environmental awareness play in empowering marginalized communities through the management of environmental justice. This emphasizes the significance of fostering connections across different fields and involving the community in raising environmental awareness.*

***Keywords: environmental justice, digital tools, marginalised communities, digital literacy, environmental awareness, environmental monitoring, and accountability mechanisms.***

## 1. Introduction

All around the world, weather and climatic extremes are being brought on by human-induced climate change, which is also placing pressure on food systems that are already under a lot of strain and prompting mass displacement [1]. The actions of humans, and the inactions that have resulted from those actions, have brought to a triple planetary crisis consisting of climate change, pollution, and the loss of biodiversity. All of this has had a significant impact on human rights, which include the right to enough food and water, education, housing, and development, as well as the right to life itself. It contributes to the perpetuation of violence and marginalization, as well as the widening of socioeconomic and gender disparities[2].

These repercussions of the global crisis are disproportionate to the situation. In spite of the fact that they contribute the least, developing and least developed countries are the ones that are most harmed. In addition, populations that are already marginalized and disadvantaged are adversely affected the most, and they have a reduced capacity to adjust to the repercussions (Hendricks & Van Zandt, 2021)[3]. There has been a growing worldwide movement, fueled primarily by young people and supported by scientific research, that is urgently demanding action to address the climate catastrophe. This movement is a response to the rising repercussions of this crisis. Despite the fact that this increased awareness and civic mobilization is essential in order to press for the radical kind of change that is required, governments, businesses, and institutions are still falling woefully short in their response (UNDP Report, 2022)[4].

The United Nations Development Program (UNDP) is of the opinion that environmental justice should be utilized to address the structural inequalities and poverty that exist in order to avoid and eradicate environmental disparities that disproportionately affect the most vulnerable individuals (Reckien et al.,

[1] Lisa Harms, 'Climate Change and Human Mobility' (2020) Climate Policy Journal.
[2] Elina Halonen and others, 'Climate Change, Inequality and Social Vulnerability' (2021) Environmental Science & Policy.
[3] Katherine Hendricks and Shannon Van Zandt, 'Unequal Exposure: Disaster Vulnerability in Marginalised Communities' (2021) Journal of Planning Literature.
[4] United Nations Development Programme (UNDP), *Human Development Report 2022: Uncertain Times, Unsettled Lives* (UNDP 2022).

2018)[5]. The concept of environmental justice refers to the equitable sharing of environmental advantages and costs among all individuals, irrespective of their racial identities, socioeconomic standings, or other criteria. It acknowledges the fact that marginalized populations frequently suffer the burden of environmental threats and do not have access to resources that encourage an environment that is sustainable and healthy (Coolsaet, 2020)[6]. Recognizing the human right to a clean, healthy, and sustainable environment was a significant step that was taken by the United Nations Human Rights Council in October of 2021. One of the most important factors that contributes to change is this right, which is essential for the right to life, food, and decent jobs, among other rights (Ebbesson, 2022)[7].

The United Nations Development Program has also introduced a new strategy that supports this effort. In order to ensure protection and justice for people who are experiencing the repercussions of the environmental crisis the most intensely and who are most likely to be left behind, it reinforces the larger environmental response that the United Nations Development Programme is providing (UNDP Report, 2022)[8].

Moreover, a multiplicity of existential concerns must be confronted simultaneously by society. These challenges include political instability, the digital divide, climate change, and maintaining environmental justice. Throughout the course of history, marginalized people have been excluded from the competition for resources in all of these concerns, particularly when it comes to seeking solutions to issues of environmental justice and access to technology (Pellow, 2023)[9]. Despite this, it is not the case that marginalized communities are incapable of fostering creativity. Technology has the potential to play a vital role in the advancement of environmental justice on the condition that it is employed carefully and not as a hack (Sikka, 2018)[10]. One of the most serious obstacles that marginalized communities face in their pursuit of environmental justice is the digital divide. When it comes to accessing critical information and participating in environmental decision-making, limited access to high-speed internet,

[5] Diana Reckien and others, 'Equity, Justice and Urban Climate Resilience' (2018) Urban Climate 1.
[6] Brendan Coolsaet, Environmental Justice: Key Issues (Routledge 2020).
[7] Jonas Ebbesson, 'Getting It Right: Advances of Human Rights and the Environment from Stockholm 1972 to Stockholm 2022' (2022) 52 *Environmental Policy and Law* 79.
[8] UNDP, Environmental Justice for All: A UNDP Framework (UNDP 2022).
[9] David Pellow, What Is Critical Environmental Justice? (Polity Press 2023).
[10] Shailaja Sikka, 'Digital Technologies and Environmental Equity' (2018) *Journal of Environmental Management*.

digital devices, and technological literacy are all factors that hamper involvement (Fang et al., 2019).

It is possible for technology to have incredible effects when it is used to provide solutions for environmental justice issues (Mendez, 2020)[11]. In addition to restricted access to resources, digital literacy gaps are another obstacle that must be overcome in order to scale up some of these solutions (McDougall et al., 2018)[12]. For the purpose of maintaining innovations in these communities and the greater environmental justice ecosystem, it is necessary to follow investments in environmental justice with increased investments in digital infrastructure and programs that are specifically designed to provide digital literacy training. One can leverage the potential of technology to promote environmental justice for all people by working together, investing in these efforts, and advocating for them (King et al., 2021)[13].

## 2. Aims and Objectives

1. To analyze the effectiveness of digital tools and platforms in empowering marginalized communities to address environmental injustices.

2. To explore the role of digital literacy and education in promoting environmental awareness and engagement.

3. To study the recent trend for the potential of digital innovations in enhancing environmental monitoring, enforcement, and accountability mechanisms.

## 3. Literature Review

### 3.1 Review of existing literature on the effectiveness of digital tools in empowering marginalized communities to address environmental injustices

In today's day and age, technology has evolved into an instrument that is absolutely necessary for enhancing the impact of environmental justice. The ability to link individuals and communities, to give

[11] Michael Mendez, 'Climate Justice and the Politics of Pollution' (2020) Yale University Press.
[12] Colin McDougall and others, 'Digital Literacy for Environmental Governance' (2018) Environmental Education Research.
[13] Lucy King and others, 'Digital Tools for Community Environmental Monitoring' (2021) Sustainability Science.

vital resources and information, and to enable inventive solutions to serious environmental concerns are all capabilities that it possesses (Figueroa, 2022)[14]. People are now able to connect with one another and work together in a way that was previously impossible. These platforms can be utilized by entrepreneurs who are interested in environmental justice to network with individuals who have similar values and perspectives, exchange information and experiences, and locate potential partners or investors. Websites such as LinkedIn and GreenBiz, for instance, offer professional communities in which individuals can connect with one another, share their thoughts, and learn about new prospects. These platforms can be especially useful for communities that are underrepresented because they offer them a fair playing field on which they can demonstrate their ideas and abilities (Houde, 2021)[15].

Furthermore, data analytics plays a significant part in environmental justice since it enables business owners to make decisions based on accurate information and recognize patterns on their own. The utilization of technology enables business owners to gather and examine data concerning environmental concerns, the requirements of the community, and the tendencies of the market (Hannah-Moffat, 2019)[16]. For instance, mapping technologies such as GIS (Geographic Information System) can be utilized to visualize environmental data, such as the levels of pollution or the accessibility of green spaces. This assists business owners in identifying regions that require immediate attention and in developing solutions that are specifically tailored to address those areas (Kraak & Ormeling, 2020)[17].

In addition, mobile applications have the ability to involve communities in environmental justice activities and to empower them to participate in those initiatives (Rickenbacker et al., 2019)[18]. For instance, mobile applications can be designed to educate consumers about environmentally responsible practices, provide information about environmental risks in the local area, or even promote community-led efforts to clean up the environment. One such example is the "TrashOut" app, which enables users to report and map unlawful trash disposal areas. This gives communities the ability to take action and

[14] Robert Figueroa, 'Environmental Justice' in B Garvey and others (eds), The Routledge Companion to Environmental Ethics (Routledge 2022).
[15] Lise Houde, 'Digital Communities for Environmental Innovation' (2021) Journal of Cleaner Production.
[16] Kelly Hannah-Moffat, 'Data Analytics and Inequality' (2019) Theoretical Criminology.
[17] Menno-Jan Kraak and Ferjan Ormeling, Cartography: Visualization of Geospatial Data (4th edn, CRC Press 2020).
[18] DeAngela Rickenbacker and others, 'Mobile Apps for Environmental Participation' (2019) Environmental Justice.

make authorities accountable for their actions (Zigova et al., 2018)[19].

Furthermore, traditional sources of support may be restricted, particularly for areas that are particularly impacted by environmental injustices. On the other hand, crowdfunding platforms such as Kickstarter, GoFundMe, and Patreon have made fundraising more accessible to the general public (Ren et al., 2020). The use of these platforms enables entrepreneurs working in the field of environmental justice to display their ideas, establish connections with possible funders, and generate cash for their initiatives. Individuals who have unique ideas but limited means will find this to be beneficial because it offers up new options for funding and eliminates the hurdles to entrance (Maehle et al., 2020)[20].

For successful entrepreneurship, it is also essential to have access to educational opportunities and opportunities to expand one's skills. Because of technological advancements, users now have the ability to participate in online courses, webinars, and seminars that cover a wide range of environmental themes. Platforms such as Coursera, Udemy, and edX provide students with access to a diverse selection of courses that cover topics such as environmental policy, renewable energy, and sustainability (Nurutdinova et al., 2023)[21]. Aspiring entrepreneurs in the field of environmental justice can improve their capacities and have a bigger impact on the communities in which they operate by obtaining new information and skills throughout their careers. As a result, technology has evolved into a potent instrument that may significantly increase the impact of environmental justice.

### 3.2 Exploration of the role of digital literacy and education in promoting environmental awareness.

Environmental education is an essential field that strives to foster ecological awareness, responsible behaviours, and sustainable practices among students. In today's rapidly evolving world, educators are embracing technology to revolutionise teaching methods and create engaging learning opportunities for

[19] Gabriela Zigova and others, 'Community Reporting Apps and Waste Management' (2018) *Waste Management Journal*.
[20] Ingrid Maehle and others, 'Digital Fundraising and Community Innovation' (2020) Journal of Enterprising Communities.
[21] Gulnara Nurutdinova and others, 'Digital Transformation in Environmental Education' (2023) Education and Information Technologies.

students. Numerous studies have emphasized the significant impact that technology can have on environmental education. Technology offers engaging and absorbed education opportunities that connect theoretical knowledge with real-world applications. Augmented reality (AR) applications have shown to be effective tools in promoting environmental knowledge and ecological consciousness among school students (Kilag et al., 2023)[22]. Through the use of augmented reality, learners are able to engage with environmental concepts, such as wildlife habitats and ecosystems, in a captivating and immersive way. By overlaying digital content onto the physical environment, AR enhances the exploration and interaction experience. In addition, digital platforms and social media have become crucial channels for fostering dialogue and facilitating the exchange of knowledge on environmental issues among educators and students (Di Tullio et al., 2021)[23]. These platforms enable collaboration and communication, providing learners with the opportunity to connect with experts, take part in global environmental discussions, and engage in collective problem-solving activities.

Although technology offers exciting prospects for environmental education, it also brings along its own share of difficulties and considerations. One of the main challenges educators encounter when incorporating technology into the classroom is digital distraction. It is important for students to stay focused on their core learning objectives, as the allure of gadgets and online content can sometimes be distracting (Sang & Simpson, 2019)[24]. It is essential for educators to find a way to balance the use of technology while still creating a focused learning environment.

In addition, it is crucial to consider the precision and dependability of information obtained through digital resources. Teachers have the responsibility of instructing students on the importance of critically evaluating online sources in order to distinguish between accurate information and misinformation or biased content. It is crucial to prioritize data accuracy and credibility, as incorrect information can greatly impact students' understanding of the environment and their ability to make informed decisions (Jardin, 2023)[25]. In addition, the digital divide can worsen inequalities in accessing technology-rich learning

[22] Renante Kilag and others, 'Augmented Reality for Environmental Learning' (2023) Journal of Environmental Education.
[23] Diego Di Tullio, Marco La Torre and Maria A Rea, 'Social Media for Engaging and Educating: Sustainability Reporting and Dialogic Communication' (2021) 11 Administrative Sciences 151.
[24] G Sang and A Simpson, 'Digital Distractions in Technology-Enhanced Classrooms' (2019) *Computers & Education*.
[25] Pascal Jardin, 'Information Accuracy in Online Environmental Education' (2023) Environmental Education Research.

environments. Students who come from economically disadvantaged communities or inaccessible areas may face challenges when it comes to accessing devices or reliable internet connections. Unfortunately, this can hinder their ability to participate in technology-based environmental learning initiatives (Facer & Selwyn, 2021)[26]. It is crucial to address these disparities in order to guarantee fair and equal access to high-quality environmental education for all learners. The viewpoints of students regarding technology integration in environmental education hold equal importance. Studies have indicated that students typically have a favourable reaction to learning experiences that incorporate technology. Using digital tools can bring a fresh and engaging approach to learning, potentially boosting students' motivation and interest in environmental matters (Katika et al., 2022)[27].

In addition, technology enables customized learning experiences that cater to individual interests and learning styles. Through the utilization of interactive simulations, multimedia content, and virtual field trips, technology has the potential to enhance the accessibility and enjoyment of environmental education for a wide range of students (Asad et al., 2021)[28]. It is important to acknowledge that the success of technology in environmental education relies on students' proficiency and familiarity with digital tools. It is essential to ensure that students have the appropriate technological abilities and engagement with digital tools in order to fully reap the potential advantages of technology integration (Cebi et al., 2022)[29].

Further, the delivery and consumption of educational content has been revolutionised as a result of the adoption of digital tools, which are highly interactive in nature. Previous research highlights the important role that various media sources, particularly social media, have in spreading awareness about the environment and motivating young people to take action. This positions it as a crucial factor in fostering a society that is conscious of the environment (Boulianne et al., 2020)[30]. These tools, in contrast to traditional forms of media, make it possible for two-way interaction, which has the potential to greatly

[26] Keri Facer and Neil Selwyn, 'Digital Technology and the Futures of Education' (2021) UNESCO Futures of Education Paper.
[27] Amor Katika and others, 'Students' Perceptions of Technology Integration in Environmental Education' (2022) Environmental Education Research.
[28] Muhammad Asad and others, 'Virtual Reality as a Pedagogical Tool to Enhance Experiential Learning' (2021) Education Research International 7061623.
[29] A Cebi and others, 'Digital Competences and Technology Integration' (2022) 113 International Journal of Educational Research 101965.
[30] Shannon Boulianne, Mélanie Lalancette and Daniel Ilkiw, 'School Strike 4 Climate: Social Media and Youth Protest' (2020) 8 Media and Communication 208.

affect the results of learning. It is emphasized by Balińska et al. (2021)[31] that Web 2.0 technologies play a significant role in enhancing students' engagement with environmental information. By enabling users to engage with knowledge in a dynamic manner, such as through simulations or interactive platforms, digital tools have the potential to provide learning experiences that are individually tailored and more significant. In addition to facilitating the knowledge of intricate environmental problems, this engagement fosters the development of abilities in critical thinking and problem-solving, both of which are crucial for environmental stewardship. By acknowledging the significance of the physical environment and adopting decisions that contribute to the preservation of that environment, environmental awareness is encompassed (Fromm, 2023)[32]. The development of complete environmental knowledge and awareness is the cornerstone of an effective environmental education program based on environmental education. Sinakou et al. (2018)[33] emphasize the significance of having a comprehensive grasp of environmental issues, which is essential for encouraging individuals to engage in environmentally conscious actions. The dissemination of environmental knowledge is significantly aided by the use of digital platforms, which are readily available and have a wide range of users. To make environmental education more accessible and efficient, digital platforms provide a wide range of resources that may accommodate a variety of learning styles and personality preferences.

### 3.3 Study the Recent Trends of digital innovations in enhancing environmental monitoring, enforcement, and accountability mechanisms.

In marginalized areas, where there has been a rise in industrialization, it is of the utmost importance to monitor the numerous air pollutants that are present in the communities, both indoors and outdoors. In humans, prolonged exposure to air pollution can have negative effects, including the development of respiratory disorders such as asthma and lung cancer. These diseases can be caused by the contaminants in the air. The use of air quality monitoring systems is extremely beneficial in terms of properly monitoring air pollution (Idrees et al., 2018)[34]. These systems enable active assessment of air

[31] Anna Balińska, E Jaska and A Werenowska, 'Eco-Apps and Pro-Environmental Behaviour' (2021) 14 Energies 4946.
[32] Erich Fromm, To Have or To Be? (Bloomsbury 2023) – referenced for environmental awareness philosophy.
[33] E Sinakou and others, 'Competences for Environmental Sustainability' (2018) Environmental Education Research.
[34] Muhammad Idrees and others, 'Air Pollution Monitoring in Marginalised Communities' (2018) Atmospheric Environment.

contaminants, which in turn enables early detection of excessive levels. Air quality monitoring stations are often distinguished by their huge size as well as their expensive installation and maintenance costs. This is the case in the traditional context. In heavily populated metropolitan areas, this limits their ability for widespread deployment, which is a significant limitation. As a result, it is essential to educate underserved people about the significance of using wearable devices to monitor the air quality in their immediate environment. In comparison to the conventional ones, wearable devices are not only more user-friendly and less expensive, but they also do not require any level of technical competence (Tong et al., 2018)[35]. Individuals living in marginalized communities should be encouraged to have a pair in their household so that they may access their surroundings. Over the course of the last ten years, there has been a major advancement in the employment of inexpensive sensor technologies for the purpose of monitoring air pollution. The functionality of these user-friendly devices includes the capacity to provide near real-time, continuous monitoring, as well as portability and low maintenance requirements (Salamone et al., 2021)[36]. Assessment of the air composition within enclosed areas such as schools, workplaces, and residences is an essential part of monitoring the quality of the air inside these buildings. The quality of the air environment is affected by a number of factors, one of which is the quantity of various gaseous and particle contaminants. Due to the fact that it does not enter sufficient amounts of external air to dilute emissions from inside sources, inadequate ventilation may cause an increase in the levels of pollutants found within. Additional factors that can contribute to increased concentrations of particular pollutants include elevated temperatures and humidity levels (Ibaseta et al., 2018)[37].

In order to monitor the air quality outside, it is necessary to measure the quantities of various pollutants, such as ozone (O3), sulfur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), and particulate matter (PM), at particular sites (World Helath Organization, 2021)[38]. Air quality sensors might be linked or communicated with other portable devices that are often used, such as smartphones, tablets, and laptops, in order to provide rapid and simply comprehensible information readings. This would be a strategy that would be ideal. An advantage of sensor development would be to contain as

[35] Tong Tong and others, 'Wearable Devices for Air Quality Monitoring' (2018) *Sensors & Actuators B*
[36]Andrew Salamone and others, 'Low-Cost Sensors for Air Pollution Detection' (2021) *Environmental Monitoring and Assessment*..
[37]Claudia Ibaseta and others, 'Indoor Air Quality Determinants' (2018) *Building and Environment*..
[38]World Health Organization (WHO), *Air Quality Guidelines: Global Update 2021* (WHO 2021).

many contaminant detectors as possible at the same time (Dincer et al., 2019)[39]. However, this would present a challenge for the majority of the sensors and integrated platforms that are currently being developed. This is because the size and complexity of the hardware and software instruments that are required to operate the various technologies are rapidly increasing (Oluwasanya et al., 2019)[40].

Ultraviolet (UV) exposure sensors are yet another technological innovation that has been made in the domain of digital technology designed to monitor environmental damage. UV radiation is the energy from the sun that reaches the earth (Zou et al., 2020)[41]. This radiation contributes to the manufacture of vitamin D, which helps to increase bone density and strength. On the other hand, exposure to excessive ultraviolet light can have adverse effects on people, including the development of skin cancer, the acceleration of skin ageing, and a wide range of other dangerous disorders (Passeron et al., 2020)[42]. In terms of the prevalence of cancer on a global scale, skin cancer stands out as the most prevalent form. Increasing public education and awareness on the subject of skin cancer, as well as promoting sun protection behaviours, is the most proactive and effective strategy for avoiding skin cancer (Aleo et al., 2020)[43].

Personal ultraviolet exposure, including both UVA and UVB, can be measured using wearable UV sensors, which can give users information that is helpful to them (Turner et al., 2020)[44]. Due to the fact that the UVA and UVB intensities are typically not instructive to the general public, the UV that is measured is typically converted to UVI or UV dosage with reference to the Minimal Erythema dosage (MED). Recent developments in tiny electronics and materials have made it possible to successfully construct ultraviolet (UV) sensors that may be worn under clothing. Photosensitive film-based sensors and electronic integrated sensors are two categories that can be used to categorize them based on their photoreaction (Huang & Chalmers, 2021)[45].

[39] I Dincer and others, 'Integrated Air Quality Sensors' (2019) *Advanced Materials* 1806739.
[40] Olumide Oluwasanya and others, 'Challenges in Multi-Pollutant Sensor Development' (2019) *Sensors and Materials*.
[41] X Zou and others, 'UV Radiation and Public Health' (2020) *Nature Reviews Dermatology*.
[42] Pascale Passeron and others, 'Skin Cancer Prevention and Sun Behaviour' (2020) *Journal of Preventive Medicine and Hygiene* E246.
[43] George Aleo and others, 'Sun-Safe Behaviours and Melanoma Risk in Italy' (2020) 61 *Journal of Preventive Medicine and Hygiene* E246.
[44] K Turner and others, 'Wearable UV Exposure Sensors' (2020) Journal of Photochemistry and Photobiology.
[45] Y Huang and L Chalmers, 'Film-Based and Electronic UV Sensors' (2021) *Sensors*.

In addition, having access to clean water is one of the most important resources that are necessary for maintaining life, and the quality of the water that people drink has a huge impact on their overall well-being and health (Forde et al., 2019)[46]. It is necessary to track the quality of water in order to guarantee that people are not drinking water that has been tainted with contaminants. Water is an essential component of life. Using traditional methods to monitor the quality of water is an expensive endeavour (Olatinwo & Joubert, 2019)[47]. These techniques, on the other hand, are not very cost-effective and require a significant amount of time, which might result in a delay in the detection and response to contaminants. As a result, there is a requirement for monitoring approaches that are both more comprehensive and practical. For the purpose of monitoring various pollutant parameters in water, a number of different approaches have been applied. These methodologies include electrochemical, physical, and optical sensing. Among these, the electrochemical sensing method is the one that is most advantageous (Seymour et al., 2021)[48].

Electrochemical and biosensors offer a technology that is both cost-effective and capable of simultaneously monitoring water pollutant parameters through a multisensory patch. As a result, these sensors are ideally suited for online monitoring of large bodies of water such as reservoirs. When it comes to electrochemical sensing, traditional glass-based sensors have significant limitations when it comes to online monitoring. This is because their responses can be influenced by different pressure and temperature conditions. On the other hand, electrochemical solid-state sensors that make use of metal–oxides (MOx), polymers, or carbon-based materials (utilizing thick/thin film technology) have been shown to be superior and are ideal for incorporation into wireless sensor networks (Manjakkal et al., 2021)[49].

## 4. Research Gap

The current study on environmental justice in the digital era is continuously evolving and has areas that require further investigation and improvement. The majority of research centres around the concept and

[46] C Forde and others, 'Water Quality and Human Health' (2019) Science of the Total Environment.
[47] O Olatinwo and T Joubert, 'Traditional vs Digital Water Monitoring' (2019) *Water SA*.
[48] E Seymour and others, 'Electrochemical Sensors for Water Monitoring' (2021) Sensors and Actuators Reports.
[49] Vidyadhar Manjakkal and others, 'Metal-Oxide and Polymer-Based Solid-State Sensors' (2021) Advanced Materials Technologies.0a

historical development of environmental justice, as well as the utilization of technology to enhance environmental awareness. However, there is limited evidence regarding the impact of digital tools and platforms on empowering marginalized communities. This study will also explore the potential of digital innovations in improving environmental monitoring, enforcement, and accountability mechanisms.

## 5. Methods and Materials

In order to accomplish the aim of the study, the current study has specifically utilised the existing literature. For this purpose, the study used journal papers, articles, books, and published newspapers that are published over a period of 6 years i.e. 2018 - 2024. The study used the boolean search strings: “environmental justice”; “technology”; “digital tools”; “marginalised communities”; “environmental awareness”; “digital literacy”; and “environmental monitoring”. All papers were originally available in English, no papers were translated deliberately for this purpose. Additionally, the study did not include any studies that were in the pre-publishing stage. Rather, only papers that were already published were included.

## 6. Results and Conclusions

The concept of environmental justice is extremely important in the process of empowering communities since it helps to raise awareness about the disproportional effect that environmental problems have on underprivileged people. Community members with low incomes and communities of colour, for instance, are frequently the ones that face the greatest brunt of the effects of pollution and toxic waste disposal sites. Environmental justice projects shine emphasis on the systemic disparities that prolong environmental harm by bringing attention to the particular injustices that are being highlighted. Through the provision of a forum for advocacy and activism, environmental justice facilitates the empowerment of communities. It is possible for communities to bring about significant change when they band collectively and stand for their rights to clean air, water, and a healthy environment. An illustrative example of such activism is the water crisis that occurred in Flint, Michigan, where locals organized demonstrations, filed lawsuits and demanded accountability after the lead contamination of their water supply occurred. A further objective of environmental justice is to guarantee that communities that are impacted by environmental issues have access to legal remedies. As part of this process, it is frequently

necessary to challenge discriminatory policies and practices that disproportionately impact communities that are marginalized. The burgeoning area of environmental justice entrepreneurship is centred on the idea of empowering communities via the implementation of environmentally responsible business practices. Specifically, this entails increasing the number of economic opportunities available within populations that have traditionally been marginalized. For example, groups such as Green For All teach and support entrepreneurs from low-income neighbourhoods in the process of developing enterprises that address environmental concerns. These businesses include sustainable agriculture and renewable energy, among others. Community empowerment is achieved through environmental justice activities through the provision of educational and capacity-building programs. Community people are provided with the opportunity to acquire the expertise and abilities necessary for active involvement in decision-making processes that have an impact on their environment through the efforts of these programs. In addition to this, it fosters partnerships and collaborations between people of the community, grassroots organizations, government agencies, and private corporations. By cooperating with one another, these many stakeholders can combine their resources and knowledge in order to more effectively solve environmental concerns. All three levels of government—local, regional, and national—are the targets of environmental justice initiatives that try to influence policy change. In order to accomplish this, it is necessary to advocate for policies that promote the physical and mental well-being of all communities, particularly those communities that are most adversely affected by environmental injustices. An example of this would be the California Environmental Justice Alliance, which was successful in its efforts to fight for the introduction of the state's innovative cap-and-trade program. This program's objective is to limit emissions of greenhouse gases and to provide funds to communities that are economically disadvantaged.

In conclusion, environmental justice plays a significant role in the empowerment of communities through the following means: increasing awareness, promoting advocacy and activism, supplying legal remedies, fostering the empowerment of communities, giving education and capacity building, enabling cooperation and partnership, and driving changes in policy. In addition, connecting with others, working together, making well-informed decisions, engaging communities, raising money, and improving their abilities are all things that entrepreneurs may accomplish through the utilization of online platforms, data analytics, mobile applications, crowdfunding, and online education. By embracing technology,

communities are able to more effectively solve environmental concerns and create a future that is sustainable for everyone.

## 7. Recommendations of the Study

Countries need to make certain that their governments respect, protect, and fulfill the right to a clean and healthy environment, which is essential for sustainable development. Additionally, we need to make sure that businesses and institutions also play their part in order to speed up the global advancement towards environmental justice. Legal frameworks at the national level that are robust and capable of fostering equitable and sustainable management of natural resources. The incorporation of vulnerable, excluded, and marginalized communities within these legal frameworks is necessary in order to provide access to justice and information and to allow them to participate in decision-making.

The establishment of accessible justice and human rights institutions with the goal of empowering disadvantaged, excluded, and marginalized communities and individuals to have access to justice and information and to take part in decision-making processes. Women and Indigenous people are potent agents of change and advocates for environmental justice, provided that they are given the opportunity to have their voices heard because they are given the place or platform to do so. In addition, women should play a significant part in the administration of land and natural resources as well as climate action; however, the laws and norms of many nations restrict their ability to assert their rights to these assets and to afford them protection. The way in which we think about the rights of future generations and the rights to a healthy environment is undergoing a transformation. It is necessary for it to involve a wide range of different segments of society in the process of formulating environmental policies and making choices.

## 8. Theoretical Implications or Managerial Implications

Considering that access to technology and digital literacy are essential components of environmental equity, this research underscores the urgent need to redefine environmental justice from the perspective of the digital era. This is an important step toward achieving environmental equity. In the manuscript, a redefining of environmental justice is proposed by analyzing the ways in which underserved populations

negotiate environmental concerns through the use of digital resources. In addition, the manuscript emphasises the significance of tackling the digital divide, which exacerbates the gaps that already exist in terms of access to resources and environmental health. It proposes that marginalized groups are excluded from crucial environmental data, advocacy networks, and decision-making processes that are increasingly mediated by digital platforms if they do not have equitable access to digital technology.

The findings of this research also motivate politicians and activists to adopt policies and technology that are more inclusive and that empower populations that are otherwise marginalized. In addition, the article encourages more investigation into the ways in which technological improvements can be utilized to build greater environmental activism and resilience among marginalized people. This is accomplished by defining digital literacy and access as vital components of environmental justice. While doing so, it poses a challenge to the paradigms that are now in place, opening up new paths for research and action. Furthermore, it highlights the necessity of policies that incorporate digital equity into the larger environmental justice agenda. The research recommends that community leaders and non-governmental organisations (NGOs) adopt and promote digital platforms that enhance community involvement, environmental monitoring, and advocacy. These platforms can be found on the internet. The report suggests that the utilization of social media, mobile applications, and other digital tools should be utilised in order to enhance communication, disseminate knowledge, and empower people to participate in the decision-making processes on environmental matters.

## 9. Limitations and Future Research

There are a few limitations that are associated with the current study; nonetheless, it does provide significant insights into the expanding field of environmental justice in the digital age. At the outset, the research only makes use of secondary data, which is information that is collected through the review of existing literature. This literature consists of journals, articles, reports, and books that are linked to the subject matter. The information that was gathered does not include any first-hand accounts from members of the general population as a consequence. For the purpose of drawing a more nuanced interpretation and findings that are more broadly applicable to the study, it may be beneficial to undertake interviews with a variety of stakeholders in subsequent research. In addition, the findings gained are solely applicable to marginalized communities however, future researchers may be able to conduct more

dynamic studies that investigate the influence of environmental justice in the digital age for the community at large.