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BLOCKCHAIN TECHNOLOGY AND SUSTAINABLE DEVELOPMENT GOALS: A SURVEY OF OPPORTUNITIES AND CHALLENGES IN PAKISTAN

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Abstract

As a decentralized distributed ledger system, blockchain technology has evolved as a game-changing instrument with the promise to greatly advance Pakistan's Sustainable Development Goals (SDGs) by improving transparency, authenticity, accountability, efficiency, and inclusion in various governmental and private sectors. Blockchain-enabled decentralized tools can raise money for development sustainable infrastructure and inclusive financial growth in Pakistan, addressing work, growth and prosperity (SDGs 8) and Innovation and industrial growth (SDGs 9) while fostering authentic and transparent governance. The government's attempts to incorporate blockchain technology into the country's economy are evident in recent regulatory developments, such as the creation of the Pakistan pilot programs for digital currencies. Blockchain technologies promise to increase supply chain management processes transparency, especially in agriculture addressing Zero Hunger (SDG 2) and No Poverty (SDG 1), by lowering fraud and inefficiencies that impede sustainable production and consumption (SDG 12).Blockchain-integrated smart grids in the energy industry can achieve Renewable and accessible Energy (SDG 7) by enabling decentralized trades on energy and effective energy management in renewable process. Blockchain-based cross-border payment and remittance systems might enhance Digital transactions with financial inclusion (SDG 10). Regardless of these opportunities, blockchain's full potential in Pakistan's sustainable development goal would need addressing issues including capacity shortfalls, legislative uncertainty, and limits in technological infrastructure. This abstract emphasizes that although blockchain presents interesting avenues for Pakistan to achieve the SDGs, its implementation requires integrated policy frameworks, investments in digital infrastructure, and inclusive governance.

Introduction

Blockchain is a revolutionary technology emphasizing innovation in security, trust, and transparency of transactions. Blockchain-based decentralized technology came into the public eye after the vogue of cryptocurrencies or Bitcoin[1]. With the passage of time popularity of cryptocurrencies is growing and innovation in blockchain technology is an indication of the trust in decentralized architecture-based application development and deployment. Now cryptocurrency is the most popular application of blockchain technology [2]. More Research and innovation in blockchain technology introduces the ability to serve in every field. The core elements of blockchain are shown in Figure 1. Blockchain based decentralized techniques can be used for many platforms that require authentic and secure systems for verifying, documenting, and transferring end-users' digital data [3], [4]. Supply chain optimization, intellectual real estate management, identity management, Educational certificates, licenses, tax and revenue collection and voting systems are the most common applications of blockchain [5].

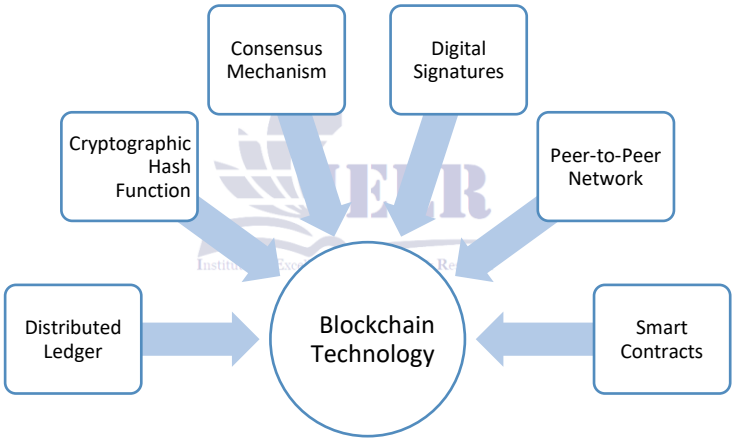

Figure 1: Main Components of Blockchain Technology

The Goals for Sustainable Development of the UN (United Nations) are a group of 17 interrelated objectives (shown in figure 2) that provide an exhaustive framework for addressing a country's development challenges, promoting inclusive development and global cooperation, mobilizing resources and measuring progress [6], [7]. These goals are intended to serve as an international appeal to remove poverty, environmental protection, and all lives prosperity ensured with the goals. In the rest of the paper, the impact of blockchain will be discussed keeping these SDGs in mind for the sustainable development of Pakistan.

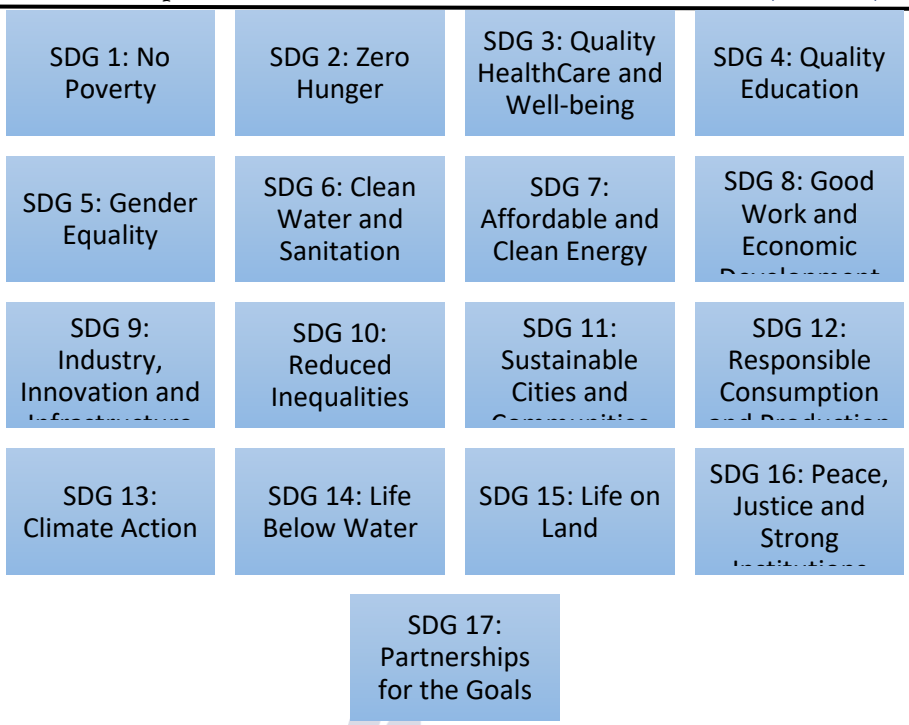

Figure 2: List of all Sustainable Development Goals

SDG1: No Poverty

Poverty is a major problem faced by millions in Pakistan. The main reasons for this poverty are unequal distribution of wealth, limited access to education, lack of economic opportunities, political instability, and limited access to healthcare [8]. In the following subsections, the role of Blockchain technology is discussed to alleviate poverty:

Financial Inclusion. Financial inclusion refers to people having access to basic financial services. It is considered one of the main factors for the reduction of poverty [9]. A bank account is considered a formal way of providing financial services that allows individuals to send, receive and store money for everyday needs and make profitable investments for the future[10]. As per the World Bank, only 20.98% of Pakistanis have a bank account in 2021 which is the fifth lowest in the World. Countries with lower percentages are South Sudan, Afghanistan, Iraq and Lebanon. One main reason described for not having a bank account by Pakistanis is the distance of banks. Consequently, digital payments through mobiles are gaining traction in Pakistan as an estimated 193 million people in Pakistan are mobile phone subscribers and the teledensity is 87.67% [11].

Banking the unbanked is becoming more feasible thanks to blockchain. Without intermediaries or the lengthy procedures associated with traditional banking, blockchain offers a smooth means of transferring and receiving money around the world. Crypto-currencies and Defi are

two blockchain based technologies that can provide basic financial services and help to alleviate poverty [12], [13]. The status of the global economy could be balanced with the help of crypto-currencies. It can level up the playing field so that everyone has access to banking and financial services, and most crucially, to financial resources.

Efficient Collection and Distribution of Zakat and Charities. Zakat is one of five pillars of Islam which reduces the imbalance of rights distribution between the wealthy and the impoverished. According to a BBC report, Zakat played a vital role in helping the poor during COVID-19 in Pakistan. Efficient collection and disbursement of zakat and charities can help to alleviate poverty to a greater extent, and have used blockchain for the collection of zakat [14]. They argue that blockchain can remove any trust issues that the zakat payers might have and ensure that the zakat amount reaches the deserving. In addition, several organizations have started using crypto-currencies for collection and distribution of zakat.

SDG 2: Zero Hunger

Pakistan is an agricultural country, however, hunger is a big problem in Pakistan. As per the Global Hunger Index (GHI), in 2021 Pakistan ranks 92 out of 116 countries and it ranks the hunger problem in Pakistan as "serious".

Food Supply Chain. Globally, more food is being produced than it can be consumed. One of the main reasons for hunger is food wastage and the inefficiency of food supply chains. In the recent past, Covid-19 and the Ukraine-Russia conflict have had an adverse effect on the food supply chains. Most food items such as fresh fruit and vegetables in particular have very limited shelf life and a slight inefficiency in the supply chain can result in their wastage [15].

Blockchain technology can facilitate global tracking, distribution, and sale of food. It can solve long-standing issues by supplying enough food, assuring its safety, and maintaining its quality, as well as reducing the adverse consequences of climate change by enhancing food sustainability. Due to its immutability and transparency, blockchain is ideally suited to handle the immense amount of data required to precisely track any type of food product, which is especially important given the enormous volume of food that is produced around the world.

Any measure to make the food supply safer can have life-saving impacts for communities at risk since poorer countries are experiencing the pandemic and climate crises' most severe effects. By extending products' shelf lives, end-to-end traceability reduces waste and makes it possible to transport food supplies effectively to where they are needed. In communities where hunger is most severe, issues like harvesting methods, budgetary limitations, and subpar packaging materials lead to food waste. Blockchain can assist in locating and mitigating supply chain inefficiencies [16]. In Pakistan, the discrepancy between food products supply and the actual demand often results in either shortage of that commodity resulting in very high prices or very low prices of the commodity due to which farmers dump their produce rather than taking it to market [17]. This

fluctuation of prices discourages farmers to cultivate the crop again next time. A blockchain-based end-to-end supply chain solution from cultivation to consumers along with trained prediction models can be used to better match the supply to demand[15]. This will help to predict the demand and enable the provision of fresh produce from the fields to the consumers.

Food Banks. Food banks are working across the globe to reduce poverty. They collect food from a number of different sources ranging from Government programs, NGOs to individuals and distribute the food among families in need. To bring more transparency in the distribution process, food banks are now shifting to blockchain based solutions. For individual's identity verification and logistics management WFP is looking at the use of decentralized architecture based technology. WFP wants to provide food for refugees. India's "Million Meal" food project aims to provide quality food and improve delivery of food, for this purpose AI, IoT and decentralized architecture solutions are used in combination [15].

SDG3: Quality HealthCare and Well-being

In Pakistan blockchain technology can be used in the healthcare sector to improve hospital management systems [18], [19]. Decentralized architecture can provide transparent and authentic plate form for sharing and storing patient important data. Through blockchain based secure systems patients can ensure that their medical records are not altered and they receive the right treatment. It increases the quality of healthcare in Pakistan in terms of security [20].

Moreover, decentralization can streamline processes related to administrative tasks such as pharmacy management and scheduling appointments by reducing maliciousness and paperwork [21], [22]. Patients' histories, lab material utilization and medicine records can maintain and update real time, which makes it easy and impacts on coordination among staff and doctors overall efficiency. In Pakistan mostly hospital records are saved manually on centralized digital systems through blockchain implementation in the health care section each individual can control their records by its own. No external entity can change, alter, update or delete any hospital instrument and patient records in the hospitals with the use of hospital digital systems [23], [24], [25].

Table 1: Analysis on the problems of traditional health system and blockchain based solutions

Terminologies	Traditional Pakistan Health System Problems	Blockchain based System
Data Security	Health sector records can be change, delete or alter	Decentralized encrypted data storage
Patient record	Inaccurate and manual	Accurate, real time and fast
Hospital Management	Delays due to poor coordination and paperwork	Updated and Associable to particular individuals

Instrumental fraud	Instruments and machines paperwork records cause instrumental frauds	Immutable and updated records of hospital machines and instruments

Healthcare Records. One area where Blockchain has huge potential is to store and manage patient health records. With more hospitals, physicians, and medical equipment available to record patient records digitally, healthcare is heading toward digitization. Medical data can now be easily shared and retrieved for use in decision-making thanks to digitization. However, this digitization poses a threat to patient privacy. Proposed a blockchain-based Healthcare Data Gateway (HDG)[26]. They ensured that no one, including the patient or doctors, could alter the medical data by using a private blockchain cloud. Important dependability and security requirements are provided in a framework for an interoperable, blockchain-based EHR. It makes it possible for various organizations with diverse internal structures to communicate with one another utilizing the organizations' current EHR infrastructure. MeDShare, a decentralized architecture-based solution for sharing pharmaceuticals data among service providers like clouds, has also been suggested by Reference. MeDShare would offer provenance, data access management, and auditing [27][28]. The same paper also suggests blocking rogue users and using smart contracts to identify data activity based on data access trends. A blockchain-based efficient data sharing system is proposed by Medchain in [29].

Blockchain can be used to create a single system for storing regularly updated medical data individually that can be quickly and safely collected by designated healthcare professionals. By minimizing maliciousness between different healthcare institutional records for the same disease and its medicine, many counterfeits can be prevented, treatment becomes possible faster with the faster diagnosis and quality health care can be possible for each patient [30].

Blockchain can also help in efficient management of medical and pharmaceutical supply chains. In combination with IoT devices, Blockchain can ensure that the necessary temperatures for various medicines are maintained. Counterfeit medicine can be identified by tracking medicine. In addition, blockchain can also be used to efficiently manage health insurance claims and audit data in healthcare[31].

SDG4: Quality Education

The education system in Pakistan needs to be improved in many areas. Traditionally educational records are not secure so external and internal entities can perform maliciousness easily. For storing educational data, a blockchain can provide a secure and tamper-proof system[32]. Educational records accuracy, student performance tracking and fraud risk reduction can be enhanced through decentralized architecture in Pakistan.

The deployment of a secure decentralized architecture in the education sector in Pakistan students admission record, educational data (attendance, assignment, quiz, lecture and lab materials) including certificates, transcripts, results and even degrees can be managed in an authentic

way [33]. Each student details uploaded on the blockchain network becomes permanent and no other entity can alter the student record means data manipulation prevention[34]. In Pakistan fake degrees have been a recurring problem. The Higher Education Commission in Pakistan has deployed a student's records on a blockchain based platform for transcripts, degrees and other educational documents verification [35].

License and Certifications. Many countries were performing research or deploying blockchain technology for license and certification authentication. For government services like license and certification blockchain technology adoption needs to require complete research work [36], [37]. Some countries that were researching or implementing blockchain technology for management of licenses and certification are given below:

- UAE (United Arab Emirates): The United Arab Emirates government departments and their services are completely based on digital systems. The UAE government has been actively performing research on the use of decentralized architecture for securing application data. License and certification management authenticity can be increased through blockchain technology.

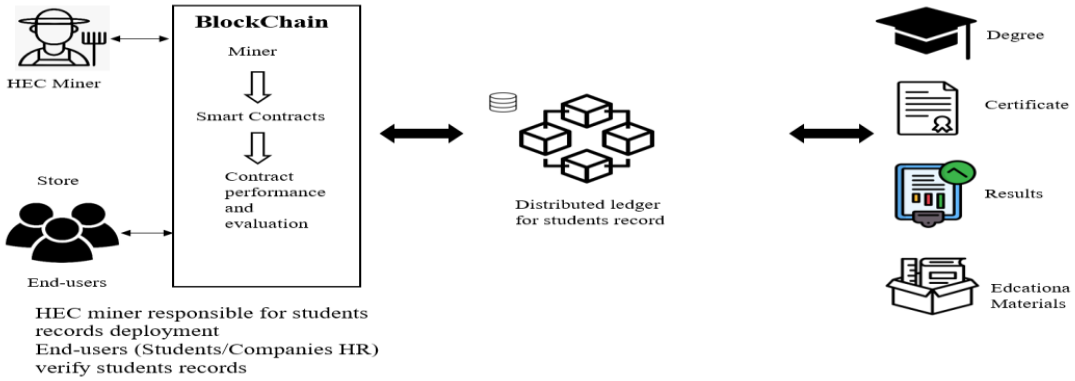

Figure 3: Blockchain based degree or education certificate verification system Architecture

- Malta: Several government and private organizations in Malta are known for their blockchain-friendly research environments. Malta education and professional qualifications sectors have been probing the use of decentralized technology for license and certification authenticity.
- Estonia: Estonia is in early stages of research on blockchain technology adoption and digital governance for various government services. Academic credentials and license management through blockchain technology are part of Estonia's government plans.
- Singapore: Singapore has been actively adopting blockchain innovations

and
investigating its utilization in different di visions including education documents and certifications.

- Georgia: Georgia government has been working with blockchain technology for land records management and other public services. License and certification management through blockchain technology also includes Georgia government plans.
- South Korea: South Korea has taken an interest in deployment of blockchain technology for authentication purposes, including licenses and certificates.
- United States: Many states in the U.S. have been piloting or exploring blockchain technology for licenses and certifications, aiming to improve authenticity, transparency, efficiency and reduce fraud.

Blockchain technology research or deployment for license and certification management in different regions of the globe can increase authenticity and trust. The level of development and deployment may vary within each country, as blockchain
appropriation is regularly driven
by particular uses-cases and government activities [38].

SDG5: Gender Equality

Property ownership rights, public services providing increased gender equality in Pakistan can be secure and transparent through blockchain based secure systems. Blockchain technology helps in women's social rights protection [39]. Blockchain technology also helps in elimination of property ownership gender based discrimination.

In Pakistan gender equality is the conviction that women have all legal rights including property ownership, public and financial services. Some work has been done in the regards of these matters but still in Pakistan women are not aware about their legal rights because of the cultural boundaries. So women cannot manage property and financial services independently [40].

The above mentioned issues can be resolved through decentralized architecture based digital systems. By managing property records through blockchain mechanism, accountability and transparency fosters in the area of land records, asset owners and inheritance. This minimizes the chance of maliciousness in women property rights in heritage, empowering women authority in financial rights with confidence [41], [42]. Women public service information cannot be altered, changed, deleted, or updated by any internal relation or any external entity, it can be done with proper authorization of that woman.

Through blockchain, the government can deploy a digital identity system for women's access to the government services like financial establishment programs and social protection programs in Pakistan directly without any need of the central identity. Through this, women in the rural areas of Pakistan are easily informed and can access the governmental resources in healthcare, education, employment opportunities and banking services [43], [44].

Identity Management System. National Database and Registration Authority (NADRA) is currently working as an identity management system in Pakistan.

NADRA is a government organization, CNICs (Computerized National Identity Cards) issuance and national database maintenance are responsibilities of NADRA. The computerized national identity card contains information on a person's personal information such as name, date of birth, photograph, and date of issuance. In Pakistan, CNIC is a primary identification document and contains a unique identification number. In Pakistan, CNIC requires access to many services like opening bank accounts and it also serves as proof of citizenship.

NADRA keeps all its data on centralized servers which is often shared with other organizations. Overall, NADRA has done an excellent job of providing identity management services to hundreds of millions of Pakistanis, however, several data breaches have been reported leading to data leaks. In 2018, a data breach was reported due to government officials sharing their passwords that were used to access personal data. In 2020, records of 115 million mobile users in Pakistan were stolen and being sold on the dark web. In 2021, NADRA's biometric data had been reported to be compromised which was used to issue illegal mobile Sims.

Blockchain technology is increasingly being used for identity management for individuals and within organizations. It has enabled individuals to have more control over sharing of personal information.

The identity management system is essential for every country that often manages identities at the national and international levels. Centralized identity management systems used in different countries are given below:

- India (Aadhaar): A 12-digit identification number is given to the nationals using a biometric-based identity management system in India. Due to the population in India Aadhaar is known as the world's second-largest biometric identification system after China. Government and private sectors use Aadhaar identification number for various services providence. Now India invests their resources to develop an identity management system based on centralized architecture.
- United States (Social Security Number) SSN: In the United States the nine-digit number is issued to United States temporary and permanent residents. The United States designed SSNs, especially for national or foreign identification and tax collection purposes. Now their focus is on the development of a blockchain-based system for identity management.
- Nigeria (National Identification Number): Nigeria assigned an 11-digit unique national identification number to legal residents and Nigerian citizens. Nigeria wants to develop a blockchain-based system for identification purposes. The existing system serves as a central identification and is used for various government and financial transactions.
- Ireland PPS (Personal Public Service Number) Number: Ireland government assigns a unique Personal Public Service Number to the national for identification. Individuals can also use PPS numbers for public services and entitlements. Ireland wants to resolve centralized architecture dependency on public services distribution.
- Uganda (National Identification and Registration Authority): NIRA is

responsible in Uganda for the identity management of persons. For identification NIRA issuance of national identification cards.

- Japan (My Number): Japan uses My Number system for social security purposes. Japan assigns a 12-digit individual number with the My Number system to Nationals of Japan for public services and identification purposes.

It's important to note that identity management systems in many countries have evolved. Some countries have multiple identity management systems for multiple purposes such as identification, tax collection, security or public services. Currently identity recognition platforms are based on centralized architecture and it is the biggest limitation of above-mentioned countries' identity management systems [45], [46].

Blockchain based centralized architecture has the ability to improve the system for managing identity of different countries according to the centralized architecture. Here are some blockchain characteristics in which blockchain can make a difference in existing identity management systems:

Table 2: Traditional identity management systems security flaws and blockchain based solutions

Blockchain Property	Description
Decentralization	Traditional identity management systems store sensitive user data in a central database, putting them in jeopardy of sensitive data breaches. Blockchain technology provides the facility for the creation of an SSI (self-sovereign identity) model. In a self-sovereign identity system, entities have control over their records or data, and an individual's data is not stored in a central storage under central authority. Blockchain technology grants access to users to their data on a need-to-know basis. This reduces the risk of data leaks and identity theft on a large scale.
Interoperability	Different countries around the globe have their own individual identity management systems but challenges are occurring in cross-border identification. Interoperability can be enabled between different identity systems through blockchain technology, providing the facility of secure verification of identities across borders.
Security and Privacy	Blockchain technology removes dependency and inherent security features, in a way of encryption and smart contract mechanisms, providing robust security and protection for individual data. Additionally, blockchain's transparency can reduce the chances of misuse or unauthorized access.
Removal of redundancy	With blockchain's immutability and non-redundancy properties, duplicate identity records can be easily eliminated, ensuring accurate identification and minimizing the risk of maliciousness.
Immutable	Once identity data is placed on the blockchain ledger, it becomes

Records	immutable, integrity assurance, authenticity and non-redundancy of the data. This can help in prevention of tampering with records identity fraud.
Consent Management	Blockchain provides a facility of control to individuals; it means only respective entities can access their data. Smart contracts utilization to ensure that entities seeking access to specific identity data must receive permission from individuals in the form of hash key values.

As blockchain technology evolves continuously, it may play a significant impact in the future of identity management worldwideTop of Form.

Public Benefits Distribution. Blockchain technology has already been explored and implemented in various countries for public benefits distribution. However, the acceptance and implementation of decentralized architecture solutions can differ between nations, and new developments will occur in future [47], [48].

Blockchain technology provides many facilities in terms of public benefits distribution, including security, efficiency, and transparency. Some countries that were researching or implementing blockchain technology for management of public benefits distribution are given below:

- Estonia: Estonia has been prominent in the world for implementing blockchain technology in its digital governance environments. Estonia specially developed an e-residency digital environment based on blockchain technology to authenticate for various public services, including voting, electricity supply, water distribution, healthcare, and other benefits distribution.
- UAE (United Arab Emirates): UAE has actively performed research on blockchain technology based solutions to enhance efficiency, reliability and security in various public benefits distribution. Their aim is to improve security, provide better services and reduce fraud to their national and foreign residents.
- Singapore: The Singaporean government has been actively investing in blockchain research to develop decentralized applications in different departments, including public benefits distribution.
- South Korea: Public benefits distribution through blockchain technology is one area that has been under consideration in South Korea.
- United States: Many states of the US have performed research on the use of decentralized architecture for public benefits distribution. Pilot programs based on blockchain technology have been launched in the United States to test the reliability, security and feasibility of public benefits distribution.
- Brazil: Brazil has been performing research on blockchain for numerous governmental services security, which also includes public benefits distribution. Brazil's government wants to improve accountability and transparency in this area.
- Kenya: The Kenya government wants to improve public service delivery by developing decentralized architecture

plate forms based on blockchain technology.

SDG6: Clean Water and Sanitation

Clean water availability and limited amounts are the major issues in southern areas of Pakistan. Water quality measurement and usage tracking are based on traditional systems. Decentralized architecture can provide a transparent and authentic platform for water quality and usage tracking. Through blockchain the risk of water pollution and contamination can easily be reduced and water usage sustainability and efficiency can easily be ensured.

Water Distribution. Indus Water Commission, neutral experts, and, as a last resort, the International Court of arbitration are all available as options for India and Pakistan to use when trying to settle disagreements. Fair distribution of water among the provinces of Pakistan has also been a big problem. It is one of the main reasons for conflict between the provinces of Pakistan. An agreement was signed in 1991 on the distribution of waters from the Indus Basin among the Pakistani provinces known as the Water Apportionment Accord. It is largely based on how much water each province historically used:

- Punjab 47%
- Sindh 42%
- Khyber Pakhtunkhwa 8%
- Baluchistan 3%.

Inter- province water disputes are handled by IRSA (Indus River System Authority) [49].

In order to guarantee equal distribution of water across a wide range of geographic areas such as in the provinces of Pakistan, a decentralized and transparent system can be created using blockchain technology. In fact, it is possible to completely eliminate any centralized organization or intermediary distributor agency that is only in charge of supplying water. Instead, a decentralized platform for end-to-end communication and simple engagement between parties to debate water conservation, preservation, and distribution can be created. Water distribution decisions can be made fairer and more transparent on the Blockchain. Transactions including the amount of water distributed, consumed, surplus water shared, etc. can be recorded using the Blockchain platform. No one will be able to tamper with the data since the Blockchain is immutable [50].

SDG7: Affordable and Clean Energy

Energy production and usage tracking can be secure with the help of blockchain based transparent and secure systems in Pakistan. Energy efficiency increases and reduces energy wastage can easily be handled with a secure clean energy system [51], [52], [53].

With the decentralized digital platform deployment, it will empower the renewable energy markets in Pakistan. Solar energy producers in Pakistan can sell electricity directly from the grid to the near hoses with the help of consensus algorithms. Transaction high cost and middlemen hurdles type issues can be addressed through blockchain mechanisms. A trust can be developed in the people's rural and urban areas to invest in renewable systems that are affordable. Clean energy adoption can be increased through this in Pakistan.

Blockchain can also strengthen government oversight and improve subsidy distribution. By employing irreversible and unchangeable data, authorities may ensure that energy subsidies, solar panel incentives, or tax advantages reach the intended recipients without corruption or poor management. This promotes fairness, boosts public trust, and accelerates Pakistan's transition to universal access to reliable, clean energy [54], [55], [56].

SDG8: Good Work and Economic Development

Economic growth is based on governmental and private organizational business transactions. In Pakistan business transactions can be recorded with the help of a transparent and secure blockchain based system to improve the country's growth [57]. This can help to create more trust between business organizations and end-users. Through blockchain, supply chain transparency and efficiency can improve, while corruption and the risk of fraud can be reduced [58].

In Pakistan many small and medium enterprises (SMEs) are struggling to gain loans even individuals due to limited authentic financial records. Enterprises manage their financial records manually on the registers or in the excel sheets that drop, alter, or delete easily [59]. With the implantation of the blockchain based system transaction histories, individual records are stored in the form of immutable, it makes it easier for investors and banks to check and verify the enterprise transactional record [60], [61]. As a result, businesses in Pakistan grow, create jobs and the economy grows.

Additionally, blockchain can improve fair working conditions and labor rights. Workers may be shielded against exploitation and wage fraud by utilizing blockchain ledgers to document employment contracts, salary payments, and working hours [62], [7]. Accountability and adherence to labor regulations are guaranteed by transparent and unchangeable records. This raises workplace standards and encourages a more productive workforce, both of which support Pakistan's long-term economic success [24], [63], [64].

Government Procurement. The World Economic Forum discusses how Blockchain can be used in fighting against corruption in the procurement process. For various reasons, governmental and public procurement is susceptible to venality. The enormity of the possible financial advantages, the close relationship between government and business, and how simple it is to conceal corrupt behavior all influence parties involved in the procurement process, whether they are public or private [65], [66].

Blockchain has the ability to guard against these flaws. E-procurement digitizes the public contracting process making it transparent and blockchain can further strengthen the process' security by encrypting sensitive data along the procurement process. This data could be tracked, monitored, and audited more readily [67], [68]. Many countries were performing research on the use of decentralized architecture for government procurement purposes, but its adoption,

development and deployment may have many challenges. A few nations that were effectively investing or executing blockchain innovation in obtaining forms included:

- United States: Many federal agencies and states in the United States were looking into blockchain technology development for procurement efficiency and transparency.
- United Arab Emirates: The United Arab Emirates government wants to enhance security of its procurement processes and reduce costs with the use of decentralized architecture.
- South Korea: A public procurement agency in South Korea is exploring the use of decentralized architecture to increase accountability and prevention against corruption in government procurement.
- Estonia: Digital government initiatives in Estonia also include streamlined procurement processes with blockchain technology potential.
- Sweden: The Swedish government wants development and deployment of decentralized architecture for supply chain management and procurement.
- Georgia: The country of Georgia is known for its digital plate forms for public services. Currently the Georgia government wants to improve the procurement process with blockchain technology as a result improve transparency and eliminate corruption.
- Canada: Some Canadian provinces like "New Brunswick" were performing research on blockchain technology deployment in public sector procurement.
- Australia: For efficiency and accountability enhancement the Australian government focuses on blockchain technology and conducting research and trials.

Taxation and Revenue Collection. Building public trust in the government and state institutions in general, and those responsible for revenue collection in particular is vital. It is often due to the lack of trust in the Government's ability to handle tax money that most Pakistanis evade tax. The government must clearly and convincingly explain what high tax rates will do for the nation and how the lives of regular residents will improve in order to convince people to part with their hard-earned money [69]. Additionally, the government must show via action that taxpayer money is used properly and responsibly [70], [71].

Blockchain has the power to improve how tax systems function. It is already in use as a tool to update current tax administrations and tax systems throughout the world. Blockchain technology is seen by governments and tax experts as a positive step toward digitizing the tax code and ongoing tax assessment [72]. Argues that the tax system in Pakistan needs an overhaul and to increase the effectiveness, openness, and security of tax collection in Pakistan, the tax system needs to be completely redesigned. Limited state capacity, poor tax collection, and corruption are some of Pakistan's most difficult and intricately entwined issues that blockchain may be able to resolve.

Many countries have been performing research on the use of blockchain decentralized architecture approaches for

taxation and revenue collection purposes [73], [74]. Here are a few nations that have shown interest in or explored different avenues regarding utilizing blockchain for tax collection:

- Estonia: Estonia has been prominent worldwide for adoption of digital security solutions in various departments, including tax and revenue collection. Estonia's government developed a blockchain based digital system called "e-Residency" that collects taxes online from businesses and provides access to numerous government services.
- Sweden: Sweden's digital tax collection agency, "Skatteverket", has been performing research on blockchain technology deployment for tax payments tracking and transparency insurance.
- Georgia: Currently Georgia deployed a blockchain technology for managing land-related data and records paid tax transactions information on land. Blockchain technology deployment in other departments like tax and revenue collection is under consideration by the Georgia government.
- Singapore: The IRAS (Inland Revenue Authority of Singapore), tax and revenue collection authority has been performing research on the use of decentralized architecture for revenue collection processes and data security enhancement [75].
- South Korea: The National Tax Collection Service in South Korea has conducted seminars on research and trials basis for the use of blockchain technology in the improvement of tax administration.
- United States: Several state-level revenue collection authorities in the US have explored decentralized architecture for tax collection, but at the federal level blockchain technology adoption has not occurred [76].

Digital Currencies. Digital currencies based on blockchain technology have had a remarkable impact on different aspects of society, like technology and finance [77], [78]. Here are some of the important impacts digital currencies have had:

Table 3: Digital currencies impact with the characteristics of security.

Key	Impact
Decentralization	Traditional identity management systems store sensitive user data in a central database, putting them in jeopardy of sensitive data breaches. Blockchain technology provides the facility for the creation of an SSI (self-sovereign identity) model. In a self-sovereign identity system, entities have control over their records or data, and an individual's data is not stored in a central storage under central authority. Blockchain technology grants access to users to their data on a need-to-know basis. This reduces the risk of maliciousness in data and identity on a large scale.
Financial Inclusion	Digital currencies follow the concept of blockchain technology and have capability to bring financial services to under-banked and unbanked populations around the globe. Blockchain technology provides access to individuals based on a decentralized architecture

	financial system. Remotely connected individuals or underserved areas can participate in the world economy.
Cross-Border Payments	Digital currencies based on blockchain technology, such as litecoin, stablecoins, and bitcoin have facilitated cheaper, faster, and more transparent transactions around the world in comparison with traditional worldwide banking systems. Digital currencies reduce transaction fees with the removal of intermediate entities and also reduce transactional times.
Financial Services Disruption	Blockchain technology has the ability to disrupt traditional financial services, including remittances, banking services, and management of assets. DeFi (decentralized finance platforms) has provided and emerged financial services of a wide range without any need for traditional entities.
Operations management Transparency	Decentralized architecture has the potential to save records from initial state to final process in a secure manner, so blockchain can improve management of supply chain systems with characteristics of transparent and immutable records of the entire supply chain process. This helps end-users to trace the origin of supply chain products, and authenticity verification [79].
Regulatory Challenges	Digital currencies and blockchain technology are rapidly growing. It produces regulatory challenges for governments of different countries around the globe.
Central Bank Digital Currencies (CBDCs)	World-wide countries central banks are performing research on the concept of Central Bank Digital Currencies. Countries are trying to introduce digital versions of their national physical currencies under control by central banks [80].

Overall, blockchain-based digital currencies are varied, with ongoing changes and developments as the technology evolved over time.

SDG9: Industry, Innovation and Infrastructure

Pakistan lacks in the fields of development. With the use of transparent and secure blockchain based systems industry, innovation and infrastructure development can be promoted. Blockchain technology keeps records and sharing data in a transparent manner helps to remove redundancy and increase collaboration in civil works [81].

By guaranteeing precision in supply chain management, blockchain may greatly boost Pakistan's industrial sector. Manufacturers can trace raw supplies, keep an eye on production steps, and verify product quality without using middlemen thanks to decentralized ledgers. This lowers fraud, boosts stakeholder trust, and raises domestic industries' total output. Additionally, Pakistani goods may become more credible in foreign markets thanks to such transparency.

By facilitating the development of algorithms (smart contract) and decentralized apps (dApps) suited to

regional requirements, blockchain also creates new opportunities for creativity. Blockchain may be used by startups, researchers, and tech entrepreneurs to provide answers for problems like digital identification, energy distribution, land ownership conflicts, and financial inclusion. This encourages a new wave of innovation-driven economic growth throughout Pakistan by fostering a culture of creativity and technological improvement [82], [83].

By guaranteeing transparent budget, schedule, and resource allocation monitoring, blockchain may enhance infrastructure development project planning, financing, and execution. Blockchain technology may be used by government agencies and commercial contractors to stop corruption and poor management in major civil projects like electricity systems, highways, and bridges. This fosters sustainable, future-ready infrastructure across the nation, boosts public trust, and guarantees timely project completion [84].

SDG10: Reduced Inequalities

The deployment of authentic and secure platforms for tracking social welfare benefits and aid through blockchain technology reduces inequalities in Pakistan. Blockchain based systems ensure that social benefits and aid are fairly distributed among needy people. Risk of mismanagement and corruption is also reduced through blockchain technology [44], [85].

Through immutable digital identity of individuals from communities that are marginalized can empower in Pakistan. Many peoples of minorities in Pakistan struggle to gain or access social services because they have not any documentation or identification. Through proper, verifiable and immutable records minorities in Pakistan can access micro loans, healthcare, welfare programs, educational and job opportunities. With this all the government development initiatives and benefits programs are equally distributed between all individuals [86], [87].

Voting System. Holding free and fair elections has always been a debatable topic not only in Pakistan but also throughout the democratic World [88], [89]. The introduction of electronic voting machines (EVMs) has recently polarized the country. Decentralized architecture can provide the security and authentic platform needed in the election process [90].

Many countries have researched or experimented with blockchain technology in recent years for voting systems, but blockchain based solution development has not yet been achieved. It's note-able that development of blockchain based applications for voting systems has many challenges like non-convenience [91], [92], [93], [94]. Several countries that have tested or developed decentralized voting systems or considered the idea are given below:

- South Korea: South Korea is known for its asset utilization in developing blockchain-based applications for different types of government services, including voting systems. South Korea has conducted small experiments using blockchain technology in local elections in a secure manner.
- Estonia: Estonia has been performing research on blockchain technology for developing voting

applications in decentralized manners to enhance security and transparency.

- Switzerland: Switzerland initiated e-voting systems concept for elections in the country. For the e-voting initiative Switzerland government also paid attention to developing blockchain based voting applications.
- Brazil: Brazil has piloted blockchain-based voting in certain regions, testing the feasibility of electronic voting systems with blockchain technology.
- United States: Absentee voting and overseas military voting are major issues in some states. These states perform research on blockchain-based voting solutions, but widespread development and deployment have not occurred.
- West Virginia: West Virginia deployed a mobile voting application based on decentralized architecture for military persons and overseas during elections.

There are various challenges and considerations when implementing voting in general elections with new technologies, especially such sensitive and complex ones as blockchain voting systems. Privacy, transparency, and accessibility issues related to such new technology systems have been the topics of debate in numerous countries.

SDG11: Sustainable Cities and Communities

Sustainable urbanization in Pakistan can be promoted through blockchain technology by providing an urban development tracking system. In Pakistan environmental pollution and degradation are increasing day by day. These problems can be controlled in sustainable and efficient manners with the help of blockchain technology [95], [96].

In Pakistan, enabling encrypted monitoring of environmental records can help build more sustainable cities. Energy consumption, water usage and management, waste dissipation and air quality record can be managed through decentralized platforms with the confirmation that data is not to be altered by any internal or external entity. With this initiative reliable information on resource consumption and pollution reaches the particular government and private agencies and even citizens. With this real and on time information respective authorities can respond on time and effectively, sustainability plans can be designed for long term on time [97].

Urban services, policies and infrastructure management can be improved through blockchain technology. Maintenance of street lights, scheduling of transport, and waste management can be improved with the deployment of smart contracts. Through this public services can be delivered transparently and smoothly, timely and reduces inefficiencies[98]. Living standard, accountability are improved through this initiative and reducing corruption in the development projects of Pakistan cities. Land ownership, permits record management, construction projects can be stored on the blockchain ledger in the immutable form. All the illegal activities can be monitored through this initiative, increasing the urban growth in Pakistan.

Intellectual Property Management. Blockchain technology has the ability to alter dramatically traditional intellectual

property (IP) management in different ways[99]. By minimizing the effect of decentralized structure and immutable nature of decentralized architecture, property documentation management can become more secure in an immutable manner[100]. Here are some intellectual property management ways in which blockchain technology can be applied:

Table 4: Blockchain characteristics impact on Land record management systems.

Blockchain Characteristics	Description
Digital Rights Management (DRM)	Blockchain technology can improve digital rights management for digital content such as audio, videos, software and e-books. Digital copyright rules can automatically be implemented through smart contracts blockchain, and confirm that only authentic entities can use, access or distribute copyrighted material[101].
Copyright Registration	Blockchain technology can be used as a tamper-resistant and time stamped registry for copyright enrollment. Owners can timestamp their invented work on the blockchain, providing a reliable data record of proprietorship and creation information. This may offer assistance in building up lawful verification of creation in case of disputes[102].
Patent Management	For patent management, approvals and filing records can be secure and immutable through blockchain technology. Patent infringement and patent process application can be streamlined through blockchain [103].
Trademark Protection	A decentralized database can be created through blockchain for trademark registrations. Verification of trademarks and search process can easily be done. This can help in identification of counterfeit products and fake trademarks [104].
Open Innovation and Collaboration	Blockchain can enable secure and transparent collaboration between multiple parties, such as researchers, inventors, and businesses. It can facilitate shared ownership of IP assets and streamline the licensing process[105].

While blockchain technology provides various advantages for intellectual property management, its implementation produces considerations and challenges. Interoperability, regulatory compliance, and scalability need to be under consideration for deployment of decentralized architecture in order to manage property documentations management [106].

Many organizations and companies are already performing research on decentralized architecture implementation for property documentations management. However, the deployment of blockchain technology is still in its early stages, and complete research on blockchain based application development is left [107]. Here are some different countries that were involved in

research on blockchain for intellectual property management:

- United States: The USPTO (United States Patent and Trademark Office) has been performing research on the use of blockchain for trademark and patent related procedures. In 2021, the United States Patent and Trademark Office generated a request for performing research on how blockchain technology can be utilized in the protection field of IP rights.
- China: China has been actively paying attention to blockchain technology usage in various fields, including intellectual property management. In 2018 the Beijing Internet Court, established, has used blockchain technology to verify digital evidence in copyright violation cases.
- South Korea: South Korea has also paid attention to using blockchain for intellectual property management. The KIPO (Korean Intellectual Property Office) has started pilot projects in country universities to explore the benefits of blockchain deployment in this field.
- Estonia: Estonia is known for utilization of blockchain based application development in public sector services. While Estonia authorities are not exclusively focused on intellectual property management. Estonia research institutions and their experience with blockchain may have development for future decentralized applications in the IP management domain.
- UAE (United Arab Emirates): The UAE government has been actively taking interest in blockchain technology based applications for numerous government services to nationals and visitors, including intellectual property management.
- Singapore: In the past few years Singapore has shown interest in blockchain technology based applications for many governmental services including intellectual property management is one of them.
- Brazil: Brazil has been putting resources into blockchain innovative work, and its government administration has taken an interest in research on blockchain based decentralized applications in different areas, including intellectual property management.

It's important that different nations and global associations may likewise be engaged in exploring or executing blockchain based solutions for IP management. Blockchain advantages with regards to straightforwardness, security, and proficiency make it an alluring innovation for taking care of intellectual property related processes.

Land Registries. The land record system that currently exists in Pakistan is reminiscent of the system started by Sher Shah Soori. Reforms were made by the Mughals and the British formalized the system. The system still relies on manual procedures, causes delays, errors, and produces deficiencies [108]. Manual record-keeping increases the chances of tampering, manipulation, and loss of important documents [109]. The opacity in the land record system creates opportunities for fraud and bribery. It becomes difficult to track the history of land transactions and verify the authenticity of land records [110]. Land disputes are common in Pakistan due to conflicting claims and forged documents. The current system often fails to provide

an accurate and verifiable history of land ownership, leading to protracted legal battles[111]. Access to land records is often restricted, requiring physical visits to government offices. This creates barriers for citizens, especially those residing in remote areas, and increases their dependency on middlemen. The centralized authority control of the land record system makes it unprotected to data breaches and unauthorized access. Any unauthorized modification or deletion of land records can have severe implications for landowners and potential investors [111].

Many countries were performing research on blockchain technology for land registry records management. However, the acquisition of blockchain technology in this field might have proceeded since 2021. Blockchain-based land registry management research initiative countries are given below:

- Sweden: Trials to test are conducted under Sweden government on the use of a decentralized system for land registry management purposes.
- Georgia: In 2016, a pilot program was initiated on blockchain-based land registry system cooperation with the Bitfury Group. Georgia became the first country in the world with this program initiative to perform research on the development of land registry systems in a decentralized manner.
- Ghana: For the removal of transparency and fraud Ghana government working on the project of blockchain based decentralized application development for land registry.
- United Arab Emirates: The Dubai government initiated "Smart Dubai" and blockchain based land registry development is part of their plan. Abu Dhabi's DPM (Department of Urban Planning and Municipalities) has launched a decentralized architecture based application for its land registry. The main purpose of the Department of Urban Planning and Municipalities is to remove security issues and reliability in traceability of land records.
- Honduras: In 2018, Honduras initiated research on using blockchain technology in the land registry system to secure land ownership records in immutable form and tackle challenges related to land tenure.
- Estonia: Estonia government performing research on blockchain based solutions for public services, not directly related to land registries. In Estonia researchers also prepared blockchain based land-related documentation which is part of various e-governance services.

SDG12: Responsible Consumption and Production

In Pakistan no availability of a single system for checking products is being produced ethically and sustainably. There is no check and balance available between product consumptions among end-users [112]. With the help of a centralized architecture system product consumption and production can be promoted by providing secure blockchain based supply chain tracking sustainability [113], [114].

SDG13: Climate Action

The promise of a centralized system to reduce carbon emissions and support the use of renewable energy in Pakistan. By offering a secure way to track carbon emissions, blockchain can help to reduce

the impact of global warming and promote sustainability in Pakistan.

By increasing accountability and transparency in carbon reporting, blockchain can greatly support Pakistan's climate change initiatives. Effective policymaking is now hampered by the lack of trustworthy systems for measuring and reporting carbon emissions in many businesses and industries [115], [116], [117]. Blockchain technology makes it possible to keep emission data on an unchangeable ledger, guaranteeing that once recorded, it cannot be changed or manipulated. As a result, Pakistan can accurately demonstrate its progress toward its climate commitments under the Paris Agreement, strengthening trust between public sectors as well as international climate authorities. Because their environmental impact can be tracked publicly, transparent reporting also motivates businesses to adopt greener methods [118], [119], [120].

Additionally, by facilitating peer-to-peer energy trade, blockchain can help Pakistan's renewable energy markets expand. Solar-powered homes and businesses can sell extra electricity to other people directly through decentralized energy platforms, eliminating the need for conventional power providers. By automating renewable energy unit pricing, payments, and verification, smart contracts can improve system efficiency and reduce corruption. In the long run, this can help Pakistan become more climate resilient by encouraging more individuals to invest in renewable technology, easing the burden on the country's grid, and fostering a shift toward green energy [121], [122], [123].

SDG14: Life below Water

Blockchain can help support sustainable marine ecosystems in Pakistan by creating a transparent and secure environment for monitoring marine conservation activities [124], [125]. This can help pollution, curb overfishing and other risks to marine life. In Karachi, Pakistan through decentralized digital system supply chain industry reliability, traceability can be strengthened. Each of the sea food supply chain steps can be recorded in the immutable form on the distributed ledger from the fish caught to the end retailer. With this initiative respective authorities can detect unregulated and illegal fishing. Regulators and end users have a surety on the fresh and authenticity of the seafood products. Seafood markets sustainability can be increased and ensured through this secure and validated digital platform. In Gwadar, Pakistan city development and port activities are growing rapidly, coastal areas pollution and disposal can also be managed through the decentralized blockchain based system. Water level and quality can be tracked in real time with the smart sensors connected to blockchain based systems where no one can change, alter, delete and update the records [126], [127], [128].

SDG15: Life on Land

Biodiversity and ecosystem restoration in Pakistan can be done with the help of blockchain based transparent and secure plate forms for storage of environmental and land use data. Promote sustainable agriculture, protect wildlife habitats and deforestation presentation can be achieved in Pakistan with the help of a secure system.

Blockchain can support green space management and sustainable urban forestry in places like Islamabad and Lahore. Local governments can monitor the development of urban greening initiatives with complete transparency by documenting information on tree planting, soil health, and maintenance tasks on an unchangeable ledger. This keeps money from being misused or tree-planting initiatives from being misreported, which is a problem that frequently arises in major development projects [129], [130]. Verified information is accessible to residents, NGOs, and government agencies, fostering community involvement in urban ecosystem restoration and bolstering trust [131], [132], [133].

Blockchain can help enhance wildlife preservation and anti-poaching initiatives in areas like Peshawar and Quetta that are seeing fast land-use change. Secure blockchain records can monitor protected area boundaries to identify illicit encroachments or logging, follow the movement of endangered species, and record conservation initiatives. Any suspicious activity can be automatically recorded and timestamped when paired with IoT sensors or drone monitoring, making it more difficult to alter or conceal environmental infractions. In addition to ensuring that land resources are managed appropriately for future generations, this produces a potent tool for protecting Pakistan's biodiversity.

SDG16: Peace, Justice and Strong Institutions

In 2021, Pakistan ranked among the most corrupt countries at 140 out of 180 countries as per transparency International. Blockchain can help promote transparency and accountability in Pakistan's public institutions by providing a secure and transparent system for tracking government spending, electoral processes, and citizen participation. Corruption can be reduced and trust can be increased in the government by promoting peace and justice in Pakistan. UNDP has identified SDG16 as one of the most important SDGs which accelerates in achieving other SDGs.

By guaranteeing clear, impenetrable records, blockchain technology might greatly improve Pakistan's legal system, including the Supreme Court, High Courts, and District Courts. A decentralized ledger can be used to store court documents, rulings, evidence submissions, and case histories so that no single authority can change or remove data. This stops unauthorized alterations, missing records, and case file manipulation all of which frequently jeopardize the legal system. Citizens have greater faith in the fairness of legal proceedings when there is a secure digital trail, which lessens political meddling and corruption.

Blockchain can facilitate effective case administration at the Supreme Court by establishing a single, transparent system for monitoring ongoing cases, court rulings, and hearing dates[134][135]. Pakistan has a huge backlog of cases, and delays are made worse by ineffective record-keeping procedures. A blockchain-based technology might guarantee that no case files disappear, automate changes, and minimize human error [136]. This helps expedite the administration of justice, supporting SDG 16's objective of

creating robust and responsible institutions [137].

Blockchain-enabled evidence authentication can also help High Courts in provinces like Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan. Due to worries about tampering, digital evidence such as papers, films, or official records is frequently contested in court. Blockchain makes it simple for courts and attorneys to confirm the legitimacy of evidence by allowing it to be time-stamped and permanently recorded at the time of submission. This improves equity and guarantees that decisions are supported by reliable data.

By making case progress, fee payments, and legal procedures completely visible, blockchain can lessen corruption at the District Court level, where the majority of citizens deal directly with the legal system. Instead of depending on middlemen who occasionally take advantage of the system, citizens might follow their cases online. Additionally, automated smart contracts could reduce delays and bribery chances by streamlining administrative duties like processing bail paperwork or issuing notices.

SDG17: Partnerships for the Goals

Blockchain can help promote collaboration and partnerships among different stakeholders in Pakistan by providing an authentic and secure system for sharing data and resources. This can help promote effective partnerships among businesses, government, civil society, and international organizations, facilitating the achievement of all SDGs in Pakistan.

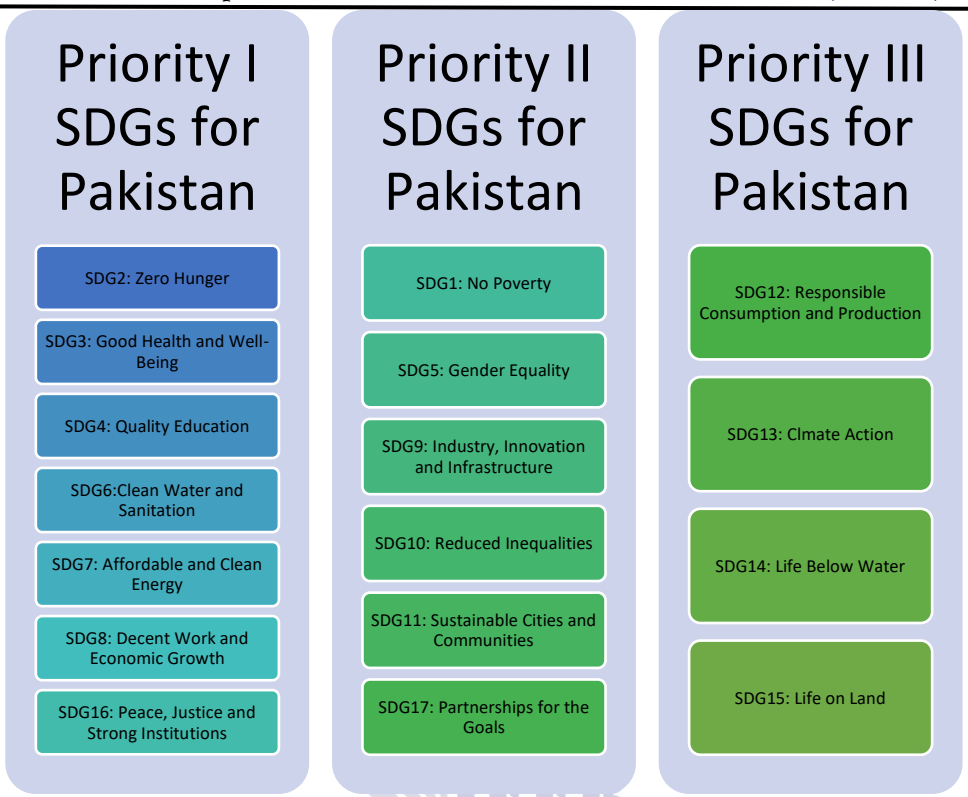

Figure 4: Priority-wise SDGs for Pakistan as per

Table 5: SDGs implementation priorities in Pakistan perspective

SDGs	Priority Status (Pakistan)	Application Area	Use Case / System	Impact
SDG 1: No Poverty	Priority II	Aid Distribution	Blockchain-based welfare ID Blockchain donor tracking	Enhances trust between donors and government, ensures real-time tracking of funds, reduces corruption in relief programs (Flood relief, BISP)
SDG 2: Zero Hunger	Priority I	Food Traceability: Agri-Finance	Farm-to-fork blockchain Smart contracts for payments	Ensures instant payments to farmers, reduces delays and exploitation, promotes financial

				inclusion in rural areas.
SDG 3: Health	Priority I	Health Records: Pharma Supply Chain	Blockchain HER Drug traceability	Creates interoperable health systems, reduces duplication of tests, improves emergency response and patient safety
SDG 4: Education	Priority I	Credential Verification: Skills Tracking	Blockchain degrees Lifelong learning records	Eliminates fake degrees, enables instant global verification, improves employability of graduates
SDG 5: Gender Equality	Priority II	Financial inclusion/ Identity Management	Digital Identity management for women	Through blockchain can ensure that all individuals have equal rights irrespective of gender.
SDG 6: Clean Water	Priority I	Water Monitoring: Infrastructure Mgmt	Blockchain + IoT tracking Smart water systems	Improves water governance, detects theft/leakage, enhances transparency in public water projects
SDG 7: Clean Energy	Priority I	P2P Energy Trading: Grid Optimization	Solar microgrids Blockchain smart grid	Improves grid efficiency, reduces outages, enables demand-response systems
SDG8: Economic Growth	Priority I	Employment: SME Finance	Smart wage contracts Blockchain lending	Expands access to finance, boosts entrepreneurship, increases GDP contribution of SMEs

SDG9: Industry & Infrastructure	Priority II	Logistics: Manufacturing	Blockchain trade systems Supply chain automation	Improves industrial productivity, enables export competitiveness
SDG10: Reduced Inequalities	Priority II	Protection socially: Financial Access	Decentralized Subsidy	Implementing policies to reduce inequalities between minorities.
SDG11: Sustainable Cities	Priority II	Land Registry: Urban Governance	Blockchain land records Smart city systems	Eliminates land fraud, reduces litigation, increases investor confidence in real estate
SDG12: Responsible Consumption and Production	Priority III	Supply chain transparency: Waste Management	Life cycle tracking	By reducing waste resources management and improving efficiency.
SDG13: Climate Action	Priority III	Carbon Markets: Climate Finance	Blockchain carbon tracking Green fund tracking	Ensures accountability in climate projects, reduces misuse of funds
SDG14: Life below Water	Priority III	Marine Monitoring: Fisheries	Blockchain based Marine Life	Sensors connected through blockchain can be monitor life below water (plants, habituates, fishes etc)
SDG15: Life on Land	Priority III	Forestry: Land Monitoring	Blockchain based Forestry	Through blockchain connected sensors life can be monitored.
SDG16: Peace, Justice and Strong Institutions	Priority I	E-Government: Voting Systems	Blockchain public records Blockchain elections	Reduces corruption, improves transparency in procurement,

				taxation, and records
SDG17: Partnerships	Priority II	Aid Transparency: Data Sharing	Blockchain donor systems Multi-stakeholder platforms	Improves coordination among donors, NGOs, and government

Conclusion. According to the survey's findings, decentralized architecture has great potential to help Pakistan achieve the Sustainable Development Goals by improving accountability, efficiency, transparency, and inclusivity in important areas like supply chains, governance, finance, agriculture, and energy. Blockchain-based solutions can strengthen confidence and cut down on inefficiencies in both public and private institutions while addressing enduring issues with poverty, food security, financial inclusion, clean energy, and sustainable industrial development. However, achieving these advantages will require overcoming significant obstacles, such as unclear regulations, a lack of technological capability, a poor digital infrastructure, and a lack of institutional preparedness. Therefore, it is crucial to have a coordinated national plan that includes investments in human and digital resources, inclusive governance systems, and clear policy frameworks. Blockchain can go beyond pilot projects to become a useful enabler of sustainable development and a catalyst for accomplishing Pakistan's SDGs with persistent support from legislators, business players, and academic institutions.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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