

## The Use of Blockchain for Water Rights in Irrigation Management

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**Abstract** The increasing pressures of climate change, population growth, and water scarcity necessitate innovative solutions for efficient water management, particularly in agriculture. This paper explores the application of blockchain technology in the management of water rights for irrigation, presenting a novel approach to enhance transparency, accountability, and efficiency in water allocation. Traditional water rights systems are often hindered by bureaucratic inefficiencies, lack of real-time data, and disputes among stakeholders. By leveraging blockchain's decentralized ledger system, this study illustrates how water rights can be tokenized, enabling farmers to trade water rights in real-time while ensuring compliance with legal and environmental regulations. This research employs a mixed-methods approach, combining case studies from regions where blockchain has been piloted for water management with qualitative interviews from stakeholders in the agricultural sector. The findings reveal that blockchain can significantly reduce transaction costs, mitigate conflicts over water rights, and facilitate better allocation based on real-time water availability. The technology fosters a participatory governance model by enabling stakeholders to engage in decision-making processes through smart contracts, which automate and enforce water allocation agreements without the need for intermediaries.

**Keywords:** Blockchain, Water Rights, Irrigation Management, Sustainable Agriculture, Resource Allocation

### I. Introduction

Climate change, population growth, and farming methods that aren't healthy are making water shortage a bigger problem around the world. Effective water management is becoming more important as the need for freshwater resources keeps going up. This is especially true in agriculture, which uses about 70% of the world's freshwater. Traditional ways of handling water rights are often inefficient, not clear, and cause disagreements between users. In this situation, the fact that blockchain technology could completely change how water rights are managed in irrigation is a very exciting chance to make water sharing more sustainable and fair. Blockchain is an independent and unchangeable record framework that's getting to be more prevalent in numerous areas, such as healthcare, managing an account, and supply chain administration [1]. Its fundamental features openness, security, and tracking make it particularly great at settling the

issues that come with customary water administration frameworks. Blockchain can offer assistance tokenize water rights by making a secure way to record and check exchanges. This will permit offering and apportioning water rights in genuine time based on real water supply and utilize. Tokenizing water rights implies making computerized coins that speak to diverse sums of water. Clients can at that point purchase, offer, or exchange these tokens [2]. This strategy lets agriculturists adjust rapidly to changing water conditions, which makes strides the way they water their crops and makes superior utilize of water assets. Savvy contracts, which are understandings that are naturally carried out and have their terms composed straightforwardly into code, can moreover make beyond any doubt that water rights rules are taken after consequently, cutting out the require for agents and the chance of contentions.

Introductory comes about appear that blockchain has made water administration much more open and effective in places where it has been tested for the primary time. Ranchers can get real-time data approximately the supply of water, which makes a difference them make smart choices around how to water their crops. Too, being able to exchange water rights in an open showcase can grant agriculturists, particularly smallholders, more control by giving them more ways to oversee their water supplies and arrange their accounts. Indeed in spite of the fact that blockchain incorporates a parcel of guarantee for managing water rights, there are a few issues that got to be settled some time recently it can be broadly utilized [3]. In order for blockchain arrangements to work with current water rights rules and government frameworks, administrative systems got to alter. Too, players like agriculturists, water directors, and legislators ought to be taught and prepared in arrange for this modern innovation to be caught on and acknowledged [4].

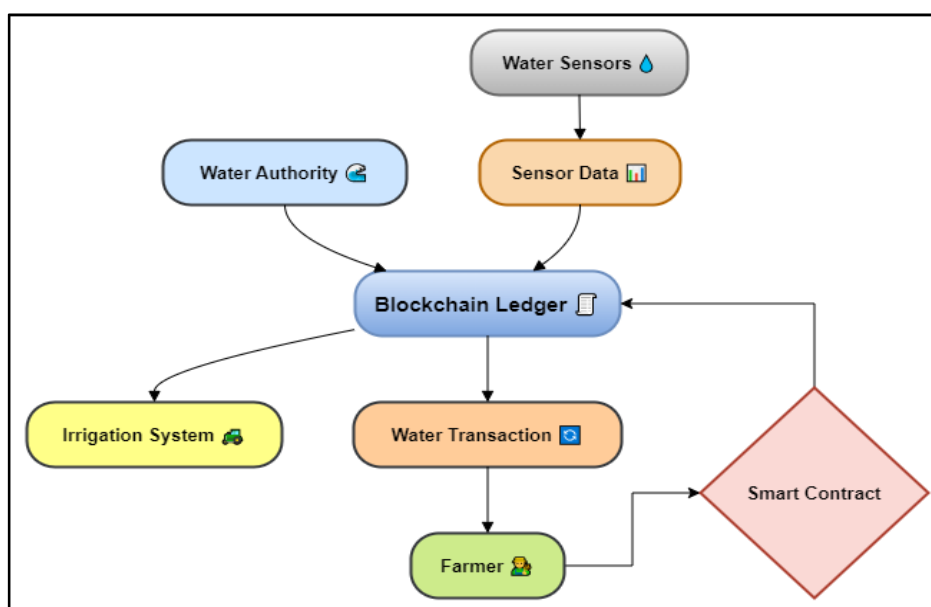


Figure 1: Illustrating Blockchain for Water Rights in Irrigation Management

The point of this study is to look into how blockchain technology could be used to handle water rights for irrigation, focusing on how it could make the process more efficient, open, and long-lasting. We are going to look at the real-world effects of using blockchain solutions in agriculture by looking at case studies and talking to stakeholders [5].

## II. Overview of Water Rights

### A. Definition of water rights

People or businesses have water rights when they are legally allowed to use water from a certain source for a certain reason. These rights determine how water is shared, handled, and protected. They make sure that people can get to water supplies while also meeting the needs of different groups. Different countries and areas have very different rules about water rights. These rules are based on history, culture, and the law. When it comes to water rights, there are two main

types: watershed and past usage. People who own land and whose land is next to a water source are given rights under the riparian system. This method is popular in the eastern parts of the US and many other countries around the world. It focuses on sharing entry [6]. On the other hand, "first in time, first in right" rules determine who gets water rights under the prior appropriation method. This system lets the first person to take water from a source keep using it, even if they don't own the land. This method is often used in dry areas, like the western United States, where water shortages are more noticeable.

### **B. Legal frameworks governing water rights**

Different places have very different laws about water rights. These laws are shaped by history, local customs, and government rules. In general, these models are meant to divide up water supplies, settle disagreements, and encourage long-term management methods. In many countries, water rights are controlled by a mix of laws, rules made by the government, and common law concepts. To give you an example, in the US, water rights are controlled by both state laws and federal rules. How water rights are distributed is based on two main systems: watershed and prior acquisition. Prior appropriation sets rights based on the order of water use, which is very important in dry areas. Riparian rights give access to water to landowners who own land next to a water source, which encourages shared use [7]. Treaties and deals that control transboundary water resources can change the laws that apply to countries around the world. These kinds of deals try to find a balance between the needs of all the countries that share water bodies by setting rules for fair and sensible use. Also, a lot of countries are switching to integrated water resource management (IWRM) methods, which stress involving all stakeholders and taking environmental needs into account [8].

## **III. Blockchain Technology**

### **A. Definition and key features of blockchain**

Blockchain is an autonomous digital ledger technology that lets computers in a network keep safe, open, and unchangeable records. Each transaction or piece of data is put into a block, and these blocks are tied to each other in order, making a chain. This technology was first made for currency like Bitcoin, but it has since been used in banking, supply chain management, and government, among other places. Decentralization is one of the most important parts of blockchain. Blockchain works on a network of nodes instead of a single authority like regular systems do. This division makes things safer and lowers the chance of data being changed or a single point of failure. Also, everyone in the blockchain network has access to the whole log [9]. This makes sure that all events can be seen and checked. Users and partners are more likely to accept this level of openness. Immutability is another important trait. Once information is added to the blockchain, it can't be changed or removed without the network's agreement. This trait makes sure that the information is correct and creates a trustworthy record of the past.

### **B. Advantages of blockchain technology**

There are many important benefits to blockchain technology that make many fields and uses better. One of the best things about it is that it makes things safer. Using security methods to protect data makes sure that it can't be changed or accessed by people who aren't supposed to. There is a high level of data security because each transaction is recorded in a way that makes it almost impossible to change past entries without changing all blocks that come after them. Another big benefit is that it is clear [10]. In a blockchain network, everyone can see the whole log, which lets them check deals on their own. This openness builds trust among users and lowers the chance of disagreements, which makes it especially useful in areas like banking, supply chain management, and government.

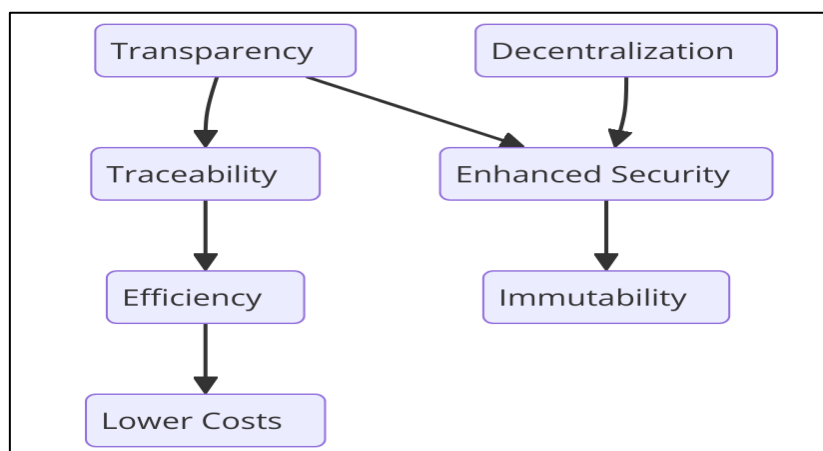


Figure 2: Advantages of blockchain technology

Another important benefit of blockchain is that it is decentralized. Blockchain lowers the risk of single points of failure and makes systems more resistant to hacking by getting rid of the need for a central authority. Users are given more power by this feature, which gives them more control over their info and activities. Blockchain technology can also save money by simplifying processes and getting rid of the need for middlemen.

#### IV. Applications of Blockchain in Water Rights Management

##### A. Recording and transferring water rights

Blockchain innovation could be a progressive way to record and share water rights that fix numerous issues with the way things are done presently. Blockchain's unchangeable and open nature makes it conceivable to record water rights in a secure and exact way. All exchanges and changes are until the end of time recorded and simple to discover. On the blockchain, each water right can be spoken to by a interesting computerized coin. This makes it simpler to keep track of who possesses what and makes complaints and tricks less likely. While moving water rights, blockchain makes the method a part less demanding. The ancient ways of doing things frequently include a parcel of printed material and long endorsement forms, which can moderate down moves and cause contradictions between parties. With blockchain, water rights can be moved right away through shrewd contracts, which are bargains that carry out their possess rules as before long as certain conditions are met. This speeds up the moving prepare and makes it less demanding to take after the rules set by the government.

##### B. Ensuring transparency and traceability

Blockchain innovation could be a key portion of making beyond any doubt that water rights administration is open and simple to track, which is vital for great government and long-term asset use. All interactions are kept on a open log that can be seen by everybody within the organize. This makes blockchain exceptionally straightforward. Agriculturists, authorities, and clients can all check water rights and utilization records in genuine time since the framework is open. Individuals who have an intrigued in water can make keen choices and believe each other more on the off chance that they can see how it is being utilized and transferred. One of the leading things approximately blockchain is that it can be utilized to track water rights in awesome detail, from where they came from to where they are presently. The blockchain keeps a total record of all exchanges and exchanges that can't be changed or evacuated. Each exchange or exchange is recorded as a partitioned square. This following is particularly supportive for settling differences almost water rights and utilization, since it gives everybody get to data that can be checked almost the past of proprietorship and exchanges.

## V. Challenges and Considerations

While blockchain technology and smart contracts offer great chances to improve the control of water rights, there are some problems that need to be solved before they can be used. The rules and regulations are a big problem. There are a lot of complicated local, state, and national rules that affect water rights, and it can be hard to fit blockchain solutions into these legal systems. Clear rules need to be made by policymakers that understand blockchain as a real tool for handling water rights and make sure it follows the rules that are already in place. Another thing to think about is the technology framework that is needed to deploy blockchain effectively. Blockchain technology may not be widely used in rural and farming places because they don't have the right digital infrastructure, like fast internet and dependable power sources. To get around this problem, it's important to put money into facilities and teaching for all parties. There also needs to be buy-in from all stakeholders. Farmers, people in charge of water, and government officials need to know what blockchain can do for them and be sure that it is safe and reliable. There needs to be a lot of training and marketing to show how blockchain can improve the way water is managed. Also, privacy and security problems for data must be carefully thought through.

## VI. Conclusion

Using blockchain technology to handle water rights for irrigation is a revolutionary way to solve the serious problems of not having enough water and not using resources efficiently. Using the cryptography features of blockchain (immutability, security, freedom, and openness) can help people in the farming industry better manage water supplies. Being able to correctly record and move water rights as digital tokens makes deals go more smoothly and cuts down on delays caused by bureaucracy and disagreements between users. Using smart contracts also simplifies the process of allocating water, which lets decisions be made in real time and adapt to changing weather conditions. This not only makes the best use of water, but it also encourages sustainable farming by making sure that resources are distributed based on real needs and patterns of use. Adding IoT devices to blockchain makes it easier to collect and analyze data, giving managers more useful information that can help them make decisions. But there are some problems that need to be fixed before blockchain can be used successfully in this situation. To reach its full potential, it needs to get rid of regulatory problems, fix technical infrastructure problems, and teach stakeholders what they need to know. Also, concerns about data safety and effects on the environment need to be carefully handled.

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