

Rethinking Forest Management: A Participatory Blockchain-based Governance Approach

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Abstract: The forest is a high-potential area for many stakeholders, provides valuable contributions to the climate, is profoundly important for sustainability with respect to resources, biodiversity, and so forth. In contrast, today's forest is frequently managed in a top-down organizational flow where some stakeholders are involved in decision-making whilst others remain uninvolved but still affected. Meanwhile, the process of digital transformation takes place in almost any realm and shows up new ways of participation and of how people can secure their interests. Against this background, we rest on scientific literature and the current forest management situation in Germany and introduce the blockchain technology as a potential enabler for a participatory management (PM) of forest. At the end, we discuss economic potential and incentives for forest owners since adoption is closely linked to acceptance of such models.

1 INTRODUCTION

The forest is a complex system with several functions for different stakeholders as it has a high importance in the endeavor of reaching climate goals, e.g., it absorbs billions of CO₂ globally every year (Canadell and Raupach, 2008) and plays an important role for the preservation of biodiversity. Meanwhile, the forest is a place for leisure and recreation for people (a recreational function). Furthermore, it provides additional services, e.g., timber supply (productive function). While recreational and productive functions increase the intensity of intervention (because exploiting the forest's productive function is in conflict to nature protection), the protection function focuses on maintenance of, for example, biodiversity, tree species composition, nature protection measures and so forth (Herbert and Kant, 2010). Overall, these functions address crucial economic, ecologic, and social value (Ní Dhubbáin *et al.*, 2007), (Karppinen, 1998).

Next, precisely these functions are those that are requested by different stakeholders – depending on her interest and their appropriate power of self-assertion. This is why forest management can be modeled as a multi-objective optimization problem where the weights are set depending on the individual

utility functions for the participating stakeholders. In this process, stakeholders are involved in and affected by forest decisions. In the end the forest is a source of natural resources to deliver raw wood, otherwise the society should benefit by its health – therefore a sustainable forest management is in everyone's interest (Food and Agriculture Organization (FAO), 2006). Hence, a balanced management is of importance.

Consequently, we argue that especially the forest as a public good might be a suitable candidate of being governed in a participatory manner instead of a single person or institution (for more reasoning, see section 2). From this point of view, our aim is to sketch a forest management vision for the future where stakeholders have the ability to participate in co-decision-making. In order to achieve this, we first introduce our use case where we describe the current situation in Germany (section 2). Following this, we introduce blockchain (here synonymously used to distributed ledger technologies, short DLT) in general and related concepts of decentralized governance. Especially as candidates that might be able to tackle such challenges arising when participatory-driven governance across multiple stakeholders is sought-after. To support our blockchain approach, we argue with the aid of a process (Wust and Gervais, 2018) helping us to answer the question if a blockchain

makes sense or not (section 3). In section 4, we present a participatory and blockchain-based forest management approach and in section 5, we highlight managerial / business opportunities and incentives to adopt such a blockchain-driven approach.

2 PARTICIPATORY MANAGEMENT

Participatory management (Guyot, 2012) is not new and already broadly examined in the context of natural resource management (Reed *et al.*, 2009), including the way how stakeholders are to be identified (Reed, 2008). This reasoning is also supported by the principle 10 of the Rio declaration on environment and development (McAllister, 1992):

“Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.”

Furthermore, participatory management is closely linked to participative decision-making and the relationship to satisfaction and performance of decisions are examined (Black and Gregersen, 1997). Nevertheless, participatory management is frequently discussed in terms of an organization instead of a public good or a natural resource, although it is further objective of research. For example, the Tanzanian government had applied participatory management for a long time and researched participatory and non-participatory forest management in over three case studies where community involvement seemed to be correlated with improving forest conditions (Blomley *et al.*, 2008).

2.1 The Forest in Germany

We describe the situation in Germany and want to motivate the suitability and importance for this approach, since current stakeholders are involved in and partly affected by contemporary forestry decisions. Therefore, the situation in Germany is the

starting point and might be applicable to other country's situations.

To illustrate this use case, we focus on small private forest owners in Germany and support our reasoning by relevant facts (UNIQUE forestry and land use GmbH, 2018): In Germany are 1.1 million people employed within the field *forest and wood*. The annual revenue is 180 billion Euro. In contrast to other countries, Germany is one of the largest exporting nation for wood and wood-products. A detailed report of the forest inventory of Germany is updated every ten years. The data from 2012 are showing that about 1/3 of Germany is filled by forest, which is equivalent to about 11 billion hectare (almost the half is held by private owners). The question of how to farm a forest is highly important. Next, with the growing awareness of sustainability, an ecological viewpoint is required. In the certification of sustainably farmed forest, Germany is a leading nation worldwide (Bundesministerium für Ernährung und Landwirtschaft (BMEL), 2008).

Although this seems quite good, it is frequently highlighted that numerous potentials are not yet exploited to its maximum. As already mentioned above, there are many private forest owners. The number of small forest owners (less than 20 hectares) is estimated at 2 billion (UNIQUE forestry and land use GmbH, 2018). In this context, potentials relating raw wood or wood reserve within small forests are assumed to be existing. Utilizing potentials allow for a more sustainable usage of a forest; consequently and among others, this may reduce dependencies on import wood, reduction of atomic power or to slow down climate change. These potentials are based, for instance, on unused wood caused by absent mobilization of wood or other objectives private forest owners are pursuing. This includes that forest owners have their own ambitions, which might contradict with the common good (UNIQUE forestry and land use GmbH, 2018). Thus, on the one hand, forest owners have main jobs apart the forest domain and the forest potentials are not utilized completely (Bundesministerium für Ernährung und Landwirtschaft (BMEL), 2008). On the other hand, a multitude of stakeholders such as hikers or environmentalists have desires that are not met.

2.2 Towards Participatory Governance

While such conflicting interests exist, we do not propose an approach to dissolve such conflicts but rather to allow participation and give the ability to exercise one's voting right. Following a set of participation requirements (Shepherd and Bowler,

1997), we derived a subset of those required to be satisfied when participation should happen in a fair manner (Innes and Booher, 2004):

Requirement 1: Since every stakeholder needs voice in order to co-decide, the entrance must be open for everyone. No access restrictions for everyone.

Requirement 2: Since every stakeholder must rely on the condition that his or her voice will be given a fair consideration, the voice aggregation procedure must be tamper-proof and in accordance with the stakeholder preferences.

Requirement 3: Since every stakeholder has to be able to see any activity, transparency across all proposals and decisions need to be guaranteed.

Requirement 4: Since every participating stakeholder has own interests and the activities and decisions are made with respect to a public good (the forest) with social and ecological implications, the overall process should be conducted in a transparent and secured manner.

Since we follow a requirement-driven approach and to satisfy these requirements, we propose an approach based on blockchain that is justified by a comparison between mentioned requirements and blockchain features.

3 BLOCKCHAIN-BASED GOVERNANCE

Blockchain is no longer just a cryptocurrency but nowadays applicable to so much more use cases, e.g. governance is gaining more and more attention in the Information Systems (IS) literature (Beck *et al.*, 2016) (Böhme *et al.*, 2015).

With requirements R1, R2, R3, R4 at hand, we propose a blockchain-driven approach for decentralized governance (Jentzsch, 2016) where participatory features (Ølnes, Ubacht and Janssen, 2017) are implemented.

For this purpose, we briefly introduce the rise and today's use of blockchain-based governance (Reijers, O'Brolcháin and Haynes, 2016). We argue that this approach can be a promising candidate for satisfying participatory requirement while taking into account the concept of decentralized autonomous organizations (DAO) – for instance implemented within the Ethereum protocol (Jentzsch, 2016). The main purpose of a DAO is the decentralized governance of “computerized rules and contracts” (Chohan, 2017) in a transparent manner. Since DAOs are essentially based on a blockchain, we use an

understanding of blockchain that gives necessary preliminaries for our approach.

The rise of blockchain, often referred to as an expression of Distributed Ledger Technologies (DLT), has most probably begun when Satoshi Nakamoto¹ had published his understanding of the blockchain technology in 2008 (Nakamoto, 2008). Therein, blockchain can be understood as one potential implementation of DLT (Cachin, 2016). As conceptualized, the blockchain potentials come from its distributed structure – resulting in the missing necessity of intermediaries. Where the trust in platforms can become a problem, blockchain provides an alternative way to interact without the need of trust (Hawlitschek, Notheisen and Teubner, 2018). Hence, intermediaries, such as lawyers, brokers, or bankers, cease to be a vital or indispensable part of transactions. Through its shared ledger and its consensus mechanisms, transactions are persistent in a transparent, immutable, and traceable way (Nakamoto, 2008) and consequently protected from deletion, tampering, and revision (Iansiti and Lakhani, 2017). Furthermore, a blockchain may offer the ability to trigger transactions automatically. This automation is possible by *smart contracts*. With this feature at hand, a blockchain is empowered to execute Turing complete programs that are able to react when certain conditions are met (based on the implemented contract logic) and then trigger events (Buterin and others, 2014).

With those smart contracts, it is possible to write DAOs as a digital and decentralized autonomous company (Swan, 2015). This concept raises popularity as it was added by the Ethereum Foundation to their public blockchain protocol (Jentzsch, 2016). It is strongly aligned to blockchain-driven governance that is decentralized and trust-less. To setup a decentralized governance on a blockchain, there might be rules that describe how the organization handles different situations when certain conditions are met (if we focus on the concept of a DAO, it definitely belongs to it). Beside the technical specifications of decentralized governance, there are also social-economic impacts on how organizations are steered and managed. Because there is no central authority on top of the organization, it is possible to create a distributed, self-organized, and non-hierarchical social structure (Reijers, O'Brolcháin and Haynes, 2016).

Furthermore, it is common sense that today's organizations are usually coordinated and controlled in a centralized way – in this case, a classical top-

¹ a person or a group of people

down flow is applied. In contrast, a DAO follows a bottom-up approach. In the start-up phase of a DAO, an initial coin offering (ICO) takes place. That way, tokens (used synonymously to coins) are offered and can be bought by shareholders who then participate in a group / co-decision decision process where different voting systems can be used (Pilkington, 2016).

3.1 How Our Requirements Justify a Blockchain

The topic around can be regarded as a hype (Carson *et al.*, 2018), this is why we argue very carefully.

On the one hand, we have our mentioned requirement for a participatory forest management vision. On the other hand, we have blockchain features that might be required. Anyway, if they are held to be required, they definitely yield a higher system complexity. To support our argument for the application of a blockchain approach, we gradually go through a process that helps answer if a blockchain is advisable for getting applied. This process is conducted and closely linked to our requirements R1 – R4 and takes blockchain properties into account such as public verifiability, transparency, privacy, integrity, redundancy, and trust anchor. The following questions are part of the decision process (Wust and Gervais, 2018).

The first question is: (1) *Do you need to store state?* Since the blockchain stores both, the forest state data and the history of participatory-driven decisions, we answer the question with yes (satisfying **requirement 3**). (2) *Are there multiple writers?* Since multiple stakeholders are involved in taking part in co-decision-making, we answer this question with yes. (3) *Can you use an always online TTP?* TTP means trust third party, i.e., a party that has trust of those involved. Indeed, this question is hard to answer. Our first assumption is that the participants (the stakeholder) have own interests and objectives – hence at least incentives exist to manipulate or tamper upcoming data in an (un)intentionally way. Our second assumption is that a participatory-driven forest management system of a public good should not be assigned to the responsibility of one single party (satisfying **requirement 2 and 4**). Therefore, the answer to this question is no; no always online TTP can be used. The next question is: (4) *Are all writers known?* Due to the openness of the forest and, consequently, the system, the answer is no. Potentially every stakeholder can decide to become part of the system and henceforth in the co-decision-making (satisfying **requirement 1**). The structure can be designed in such a way that every stakeholder is

able to participate and access is not restricted to anybody.

According to the proposed process, the recommendation is that a *permissionless blockchain can be a technical solution*. Taking this into consideration, we sketch a participatory and blockchain-based governance approach for a visionary forest management alternative in section 4.

4 A PARTICIPATORY FOREST MANAGEMENT

We describe a forest management approach enabling stakeholders to co-decide while the forest owner dispenses from its right to decide solely. At this, a stakeholder can put his preference into a superordinated co-decision-making process, which is embedded in a participatory forest management (PFM), see Figure 1.

4.1 The Life Cycle Process

The PFM is modeled according to the Business Process Model and Notation (BPMN), where we differentiate between three stages: (1) a construction phase that acts as long as the start-up continues and which embraces all nodes until the state *Tokens emitted*. Afterwards, (2) an operational phase that acts while the system is running and spans until the shareholders decide against its further existence (after the event *Voting finished*). For the sake of completeness, the life cycle (3) ends with a deconstruction phase.

First, the PFM is non-initialized. The process starts with the willingness of the forest owner to adopt a PFM. Hereafter, the **construction phase (1)** initializes the state of the forest by inserting the forest inventory data into the blockchain (database Forest State Data (DB) in Figure 1). Next, a *forest invariant* (FI) is derived. We use the FI to describe a desired state of the forest. The data stored in the (blockchain) DB has to fulfil the conditions of the FI. The forest invariant is satisfied as long as the described state is fulfilled by the forest. The real data is stored and maintained in the DB, i.e., while the DB contains specific values representing the state of the forest, the FI describes the valid value ranges which DB data has to fulfil. The invariant is a describing ruleset that, for instance, consists of basal area (a factor indicating the timber stocks) or the amount of timber for energy purposes. Those condition attributes describe the desired real-world state of the forest and have to be

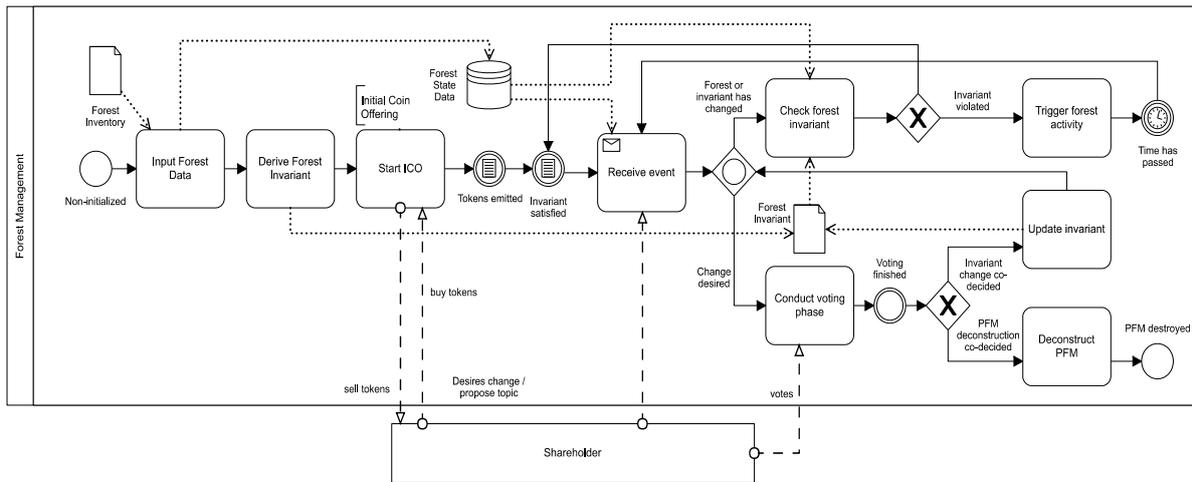


Figure 1: Life Cycle Process of a Forest Management System.

compared periodically. In the participatory process, the shareholders have to exercise their voting right to agree on conditions. The initial value for the FI is derived by the current state of the forest. After the construction phase has finished, the FI is satisfied. However, as time passes, the forest is changing by deforestation, forestation or other natural and non-natural affecting activities.

In the last activity of the construction phase, with *Start ICO* the Initial Coin Offering (ICO) is conducted, i.e., every stakeholder has the opportunity to buy or sell shares (tokens in a blockchain meaning) and hence to gain voice to co-decide. Once a certain amount of shares has been emitted, the construction phase ends with the event *Tokens emitted*.

The next nodes focus on the running system, the **operational phase (2)**. The first node is an event and indicates that the forest satisfies the FI condition. Whenever an event occurs, the *Receive event* activity catches the signal and propagates the flow further. An event can be stimulated by shareholders endeavors or by forest changes. Shareholders might express wishes towards the forest and trigger polls by proposing a topic to which every shareholder can vote - a voting phase is conducted and finished by the *Voting finished* event. In the *Invariant change co-decided* flow, every voting has a result possibly affecting the FI, i.e., that means the shareholders can collectively co-decide on the FI. Afterwards, the flow goes back to the gateway and follows the *Forest or invariant has changed* flow. Since the invariant has changed by the FI update and whenever the shareholders conduct a voting, the next activity is to check if the invariant is still valid. That activity takes the invariant and ensures that the current forest values satisfy the FI. While satisfying, the flow goes back to the *Invariant*

satisfied event. Otherwise, there are any deviation from the wished forest state and the FI condition is violated. Consequently, the system automatically triggers compensating activities leading to forest state changes again (the *Time has passed* event indicates that time is needed and should elapse after activities have been triggered). This is a loop starting from *Receive event* to the *Time has passed*. The exit condition is met whenever the forest state satisfies the FI.

After a voting for deconstruction has finished, the branch *PFM deconstruction co-decided* will be taken, that means the shareholders have to co-decide against the further existence of the participatory forest management system. At this point, the outcome is the **deconstruction phase (3)** via the activity *Deconstruct PFM* and ends with the event *PFM destroyed*.

4.2 Special Characteristics

Beyond the life cycle process discussed beforehand, there are further explanations worth considering to provide a comprehensive understanding.

Data Insertion. The immediate action is to insert the forest inventory data into the blockchain database. Attention should be paid to this point, as both storage capacity and authenticity of data being inserted are critical. First, large amounts of data may usually be stored in distributed cloud file storages instead of multiplying them across all blockchain nodes (Wilkinson, Lowry and Boshevski, 2014). This way, data aggregations can be used to reduce the amount of data. Second, ensuring data correctness is

challenging. While blockchain let contracts and data become solid and tamper-proof, that the data are correct and represent the reality can not be guaranteed. To tackle this problem in the forest domain, it might be mentionable that the forest is publicly visitable and everyone is able to verify the data. Lastly, in a participatory forest management, we could also argue that the data insertion process might work in a participatory manner.

Token / Shares. Tokens are part of the incentive schema on blockchain (Catalini and Gans, 2016). Typically, tokens are shares held by shareholders where every stakeholder might become a shareholder. A decentralized organization such as a PFM has assigned a token that, in turn, has a demand-driven course. That way, every shareholder has an interest to behave according to the interests of stake- and shareholders since they all affect supply & demand.

Voice to Co-decide. Voting systems are established to coordinate among participating members (Osgood, 2016). The voice gives someone the right to co-decide or to propose topics. Every stakeholder has that right as he or she has become a shareholder by buying tokens. An example for a co-decision might be the voting question whether the amount of timber for energy purposes should be increased (to apply the example mentioned above). In this regard, the existence of a multi-stage voting system could be discussed where veto power is given. A forester or an environmentalist might have veto power to pursue legal purposes or higher interests.

5 HOW ECONOMICAL INCENTIVES MAKE NEW BUSINESS MODELS POSSIBLE

We believe that our PFM vision will both target inequalities among affected stakeholders and offer new business opportunities to create economic values. Here, we discuss a business model innovation disrupting established forest business models by utilization of blockchain benefits. The main disrupting fields can be described alongside the *Business Model Canvas* (Osterwalder and Pigneur, 2013) where we have innovations especially in the sectors of *Value Propositions*, *Customer Relationships/Segments* and *Revenue Streams*. The newly items of the value proposition are the transparent state and activities concerning forest as

well as the participation process itself. Moreover, the opportunity to generate additional income through new revenue streams by novel services offered in the context of forest is limited to the wealth of ideas of the shareholders; a completely new set of services based in the forest is imaginable. These services in turn generate new income opportunities. For example, the monetarization of ecosystem services is expected in the future. Ecosystem services describe ecosystems that influence human well-being. The underlying economic value was estimated by the EU at 200 to 300 billion euros. This high economic value is hardly used (Knocke, 2017). The decentralized participation of new stakeholders could make use of these ecosystem services and create additional income streams, especially for forestry enterprises.

In order to make these innovations possible, it is necessary to set incentives for forest owners so they have an interest and increased willingness in handing over the freedom to decide to others. The benefits for a forest owner are, on the one hand, the increased liquidity after (s)he has sold shares (of a well-managed forest) and, on the other hand, the accruing income by margins of additional services. Another factor is the relief provided by a participatory forest management, i.e., since participation steers the forest management, the forest is managed without active further intervention by the forest owner. This is in line with the above introduced fact that small forests are often not well managed because small forest owner's main jobs are possibly apart from the domain of forest and its management (UNIQUE forestry and land use GmbH, 2018). From shareholder's point of view, the incentive to buy shares is justified by getting co-decision voice to be able to co-decide. Moreover, there is an economic incentive to act in common interests and on behalf of the forest since the attractiveness of forest shares is reflected in the price of tokens. Share-based returns on services could also be expected from economic effective forest management.

Beyond the possibilities of an innovative business model, the legal aspects of DAOs and the Smart Contracts on which they are based must be taken into account. Since a permissionless blockchain knows no borders, it must be secured by law internationally. Contract law varies widely from country to country, so it is difficult to make a general statement about the legal enforceability of smart contracts. In order to create a framework that, like the current legal system, regulates conventional contracts, the following points must be clarified: contractual capacity, loss of contract due to errors, identification of an offer and acceptance, follow-on contractual relationship,

security of conditions and interpretation of the contents of judges and lawyers (Giancaspro, 2017).

6 CONCLUSION

With our work, we have proposed a participatory forest management by applying benefits of the blockchain technology. To use blockchain for governance purposes is not new (Reijers, O’Broicháin and Haynes, 2016), but it seems still not be examined intensively so far. With respect to participation and forest management, there is – to the best of our knowledge – no contribution so far. Hence, we have sketched a visionary participatory forest management aiming at a reduction of inequalities between stakeholders, to set economic incentives for the benefit of the forest owner to reach a better common good by incorporating claims of different stakeholders. Limitations of this system are numerous, i.e., from the specific design of the mentioned life cycle activities, the legal aspects, the complexity, acceptance, usability of the system, and so forth. Potentials, on the other hand, are possible in ecological, economical, and social areas by inherent blockchain features, for example transparency, immutability, openness and automation of technical processes. Following this, further research might focus on the feasibility of those potentials and the question of how to treat the mentioned limitations, e.g., to address the power structure for decision-makers: distribution constraints of tokens to shareholders, number of shares per shareholders to prevent too much control per stakeholder. Overall, blockchain is a promising candidate to disrupt business models (Hwang *et al.*, 2017), (Oh and Shong, 2017), to change the way people take part in co-decision processes (Lafarre and Van der Elst, 2018), and – in our opinion – to allow participation in the forest management for the future.

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