Blockchain-based Governance for Social Welfare in the Forestry

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Abstract.
While the future must be aligned more ecologically, different intensive challenges arise for the society. We exemplify these challenges by the multi objectives of a forest, since it offers renewable resources, conserves biodiversity, acts as a carbon sink, and provides recreational functions in a simultaneous manner. We approach the forest management problem (FMP) by using multi-criteria decision analysis (MCDA) with diverging stakeholder preferences as input and social welfare across participating stakeholders as output. To reach social welfare, we focus on mechanism design to gather truthful stakeholder valuations. Hence, this research in progress presents an instantiation of the participatory MCDA in the context of forestry. The research objective is to examine how distributed ledger technologies (DLT) can help to implement the mechanism and to coordinate the participatory MCDA transparently and securely.

Keywords: Blockchain, Forest Management, Social Welfare, MCDA, Governance

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1 Introduction

The forest is a complex system that offers several ecological, economical, and social services [1], while the demand for these services varies greatly and depends on preferences of heterogeneous stakeholders [2]. Involvement of stakeholders in the planning process and exchanging information transparently [3], binding, reliable, and transparent participation [4, 5] and similar activities promise to increase public commitment, the acceptance of decisions, and might help to reduce distrust between parties involved [6].

While stakeholder preferences diverge in forestry and their focus, besides others, is on timber harvesting, recreation, water supply, or biodiversity conversion, it oftentimes results in multi-criteria decision analysis (MCDA). MCDA itself is a powerful methodology to incorporate diverging preferences, to solve such multi-objective problems and has therefore been proven to be a valuable methodology in the forestry [7] over the last three decades [3]. Many MCDA approaches were combined with group decision-making [8], which have also been applied in public participation for the forestry [9] (in the following pMCDA). Today's forest decision making usually follows a top-down principle, i.e., the forest decision power distribution is quite concentrated (e.g., by the forest owner), while other stakeholders remain affected by, but are not involved in forest decision making. Our assumption is therefore that forest management must be more aligned to the overall interests to take full effect for the society. Consequently, we build on this research with the question on how to reach social welfare by means of pMCDA. For this purpose, we show that distributed ledger technologies (DLT, also known as blockchain) can help to reach social welfare (by using mechanism design theory (MDT) [10]) and to coordinate the pMCDA, since it is capable to exercise the role of a trusted third party (TTP). Although DLT was initially discussed with cryptocurrencies, nowadays applications reach from voting systems [11] to digital organizations [12], partly positioned in the field of cryptoeconomics. Additionally, DLT-based governance is gaining popularity [13, 14] and is also discussed in bioeconomy [15, 16].

Following the steps of design science research (DSR) [17], we first put a problem formulation and motivate it by describing the current situation in Germany. After that, we derive solution objectives for an IT artefact in a requirement-driven manner and conclude our research in progress (RIP) with further research steps.

1.1 Problem Formulation

The forest is a common-pool resource (CPR) [18], since it is non-excludable (nobody can be prevented from consumption) and partly rivalrous (someone's consumption subtracts the good and overuse might be an outcome). Therefore, stakeholders compete by having diverging preferences that can be classified along forest functions [19]. To give impressions of who is meant by this, consumers and the wood processing industry request the productive function. Environmentalists are interested in protecting the nature and maintenance of sustainability und hence address protective function. Those stakeholders seeking rest in the forest, for instance enjoying the nature

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and doing sports in the forest (like hikers or mountain-bikers do), request the recreational function.

To formalize this, we define m alternatives $(a_1, \ldots, a_m)$ to manage a forest, and l criteria $(k_1, \ldots, k_l)$ each alternative consists of (as usual in MCDA). The forest is assumed to be held by one private forest owner o and offers many valuable services that are requested by multiple stakeholders $N = \{1, \ldots, n\}$ in different ways [1]. Therefore $v_i: A \to \mathbb{R}$ maps a forest management alternative $a \in A$ to i's valuation for it. According to this and to a linear utility model [20], i's valuation for alternative a is $v_i(a) = \sum_{k \in K} \beta_{ik}(a)$, where $\beta_{ik}(a)$ is i'th part-worth utility of criteria k at alternative a. We assume $v_i(a) > 0$ to emphasize every stakeholder's valuation to be positive by any alternative a through forest services (recreation, nature protection etc.). To operationalize a management alternative a, realization costs are given by $c: A \to \mathbb{R}$, which are allocated among stakeholders, such that each stakeholder $i \in N$ is incurred by $c(\mathrm{a}) = \frac{c_a}{|N|}$. Then, $U(A)$ is the set of all possible utilities and i's individual utility $u_i \in U(A)$ is $u_i(a) = v_i(a) - c(a)$. The vector $u \in U(A)^N$ consists of all utility profiles $u = (u_i, \ldots, u_n)$ and a social choice function $SCF: U(A)^N \to A$ returns a specific alternative.

As usual for a common-pool resource (CPR), stakeholders' conflicting objectives result in inevitable tradeoffs among feasible solutions. This way, satisfying each stakeholder $i \in N$ with highest total valuation $v_i(a) = 1$ for any alternative $a \in A$ is not possible, while each stakeholder i is assumed to be rational and therefore interested in maximizing its individual total utility $\max_{a \in A} u_i(a)$. This, in turn, increases incentives to behave strategically. An alternative that maximizes *social welfare* to be optimal is called *efficient*. We denote by $SW^N(a) = \sum_{i \in N} u_i(a)$ the social welfare of stakeholders N given the alternative a. Consequently, given a stakeholder i preferring alternative a is incentivized to maximize $SW^N(a)$ by signaling a possibly untrue valuation that is possibly higher than its true $v_i(a)$. This way, the alternative a gets more weight in a given social choice function SCF than justified and the social welfare is threatened to be inefficient. However, to permit for participation, the forest owner o needs to be incentivized to cooperate. As we assume o to be economically driven [21] and also to be rational, its total utility $\hat{u}_o(a)$ consists of its benefit (e.g., returns) minus costs (e.g., time, money) and is also to be maximized $\max \hat{u}_o(a)$.

To illustrate this, we put the focus on the forest situation in Germany, where private owners hold forests by about 25 % of the overall forest area, while forests make up around a third of the whole area of Germany (most private owners hold small forest being smaller than 20 hectare) [22]. As a result, the decision power is usually quite concentrated. Some stakeholders are eligible to decide while other stakeholders remain uninvolved although they are affected by forest management decision.

2 Objectives of the Solution

To apply forest management that is more aligned to societal needs, e.g. by allowing for participation, is discussed scientifically [3–6]. To use DLT to coordinate e-voting in general [11] or for participation [23] is also discussed. Recently, DLT has been

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discussed in the field of forest governance [15, 16], yet without pMCDA and without reflecting social welfare. Social welfare, in turn, is discussed in Game Theory to collectively decide the a public good provision [24]. To the best of our knowledge, to use DLT to reach social welfare in forestry by using pMCDA is not discussed so far. To enumerate the objectives of a solution for the above-described problem, we argue in a requirement-driven (labelled with Req) manner: Since stakeholders are involved in the pMCDA and decision power is distributed across the participants, the architecture follows a separation of ownership (forest owner) and control (stakeholder). Hence, a principal-agent problem is instantiated and the governance architecture must take self-monitoring, self-reward, and self-punishment into account [25] (Req 1). To allow stakeholders to take part in the pMCDA, the entrance must be open for everyone (Req 2). Without suspecting every stakeholder to follow tampering intentions, they still have incentives to do so since every stakeholder's expected true valuation is $v_i(a) > 0$. According the idiom "Trust, but verify", we hence argue that the solution design (Req 3) should be transparent and tamper-resistant [16], especially with respect to common-resource pool activities [26]. Since achieving social welfare requires the stakeholders to signal their valuation truthfully (Req 4), i.e. in an incentive compatible or strategy-proof manner, side payments are commonly used for it [10]. Moreover, there is a need (Req 5) for a methodology to turn multi-criteria problems into one single solution (MCDM). Stakeholders must be able to understand and to accept the MCDM methodology. Because forest management is a hard and complex task requiring forest expertise, robust and well-wrought alternatives must be incentivized to be present (Req 6), where stakeholders can (dis-)agree to. Lastly, the forest owner needs incentives (e.g., by win-win-situations [27]) to cooperate (Req 7).

3 Further Research Steps & Outlook

According DSR, further research should embrace the design, demonstration, evaluation and communication of the artifact. The artifact should be designed along the mentioned requirements (Req) and upon previous research to a participatory forest management (PFM) system [16]. For Req 1, different DLT-token-based decisions rights (decision management and control rights) can be considered due to accountability and incentives for decisions alike [28]. Req 2 and Req 3 can be covered by a permissionless and – for security reasons – widely established DLT, e.g., Ethereum is a promising candidate since its high level of decentralization and maturity [29]. MDT supports to reach social welfare and a mechanism can be implemented on-chain (by DLT and smart contracts) to focus on Req 4 [24, 30]. Especially at this, DLT acts as a trusted third party (TTP) eligible to face with smart contracts and tokenization the *preference elicitation* and the *preference aggregation problem* of MDT [10]. DLT is further capable to coordinate the pMCDM process itself [3, 7] (Req 5). For Req 6, (non-)pecuniary incentives should be discussed to make alternatives present to which stakeholder might (dis-)agree to. As valid for other DLT applications, beyond the integrity within the DLT itself, data quality on the input side must also be ensured here.

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Further steps should consist of design and development, demonstration and evaluation of a theoretically finalized PFM artefact. The proposed model should be analyzed theoretically and technology acceptance findings might be advisable.

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