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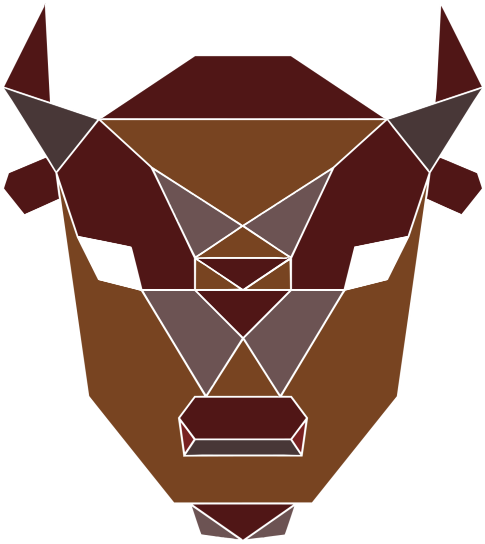

Model Proposal: Bisons Unchained

Leveraging blockchain technologies for environmental protection, economic development and community empowerment in the context of the Carpathians in Romania.

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1. Introduction

Context of Conceptual Challenge

As part of the BETH Hackathon 2019, sustainability challenges were to be solved by applying the blockchain technology. WWF Switzerland and Romania is one partner of the COSS department of ETH Zurich for this week. WWF Romania has one of its offices in the Southwestern Carpathians, where it primarily focuses on bisons as important landscape architects. Those European bisons as well as the local virgin forest are at risk due to destructive behavior of local companies and habitants.

For a long time already, WWF acknowledges the two-sided problem that several ecosystem services are not monetarily accounted for while humans tend to act according to short-term economic profit. Thus, human behavior frequently contradicts actions that would benefit the sensible ecosystems in their proximity. In order to couple the well-being of the environment with socio-economical aspects for the community, WWF investigates new technologies and corresponding application possibilities within their projects, including the blockchain technology.

Geographic Area

The Carpathian mountains are the third longest mountain range in Europe. They span across the Czech Republic, Poland, Ukraine, Romania, Slovakia, Hungary and Serbia. Their highest point is called “Gerlachovský štít “ with a height of 2,655 m. The mountain range is of considerable importance for and home to Europe’s largest population of brown bears, wolves, bisons, and lynxes.

In the Southern Carpathians of Romania, the concentrations of those animals are especially high. This part of the Carpathians constitutes Europe’s largest unfragmented forested area (WWF, 2011). WWF classified more than 11,000 hectares as virgin forest, of which about 6,000 hectares has already been permanently protected. Nevertheless, illegal harvesting of natural resources and poaching are substantial problems in this region (WWF Austria, 2018). Within WWF’s region of interest, there are approximately 2,500 inhabitants and approximately 100 of them can be considered as hunters and gatherers and are therefore part of the focus group (personal communication with Mrs. Oana Mondoc, WWF Romania, February 13, 2019).

2. Literature Review

The first to present a cryptographically secured chain of blocks were Stuart Haber and W. Scott in 1991 (Haber & Stornetta, 1996). The concept of blockchain as a decentralized, distributed ledger was further described by a person under the pseudonym “Satoshi Nakamoto” in the whitepaper to Bitcoin (Nakamoto, 2008). The important improvement compared to the previous work in 1991 was the Hashcash-like process, with which blocks could be added to a chain without the need of an action by a trusted third party. In the following years, Bitcoin further developed due to improvements suggested by individual Bitcoin users which were eventually accepted by majority decisions. Simultaneously, more and more businesses actually use bitcoins (tokens) as a payment currency, while the blockchain grows as it constitutes all transactions ever made.

Until today, 2019, possible applications of the blockchain technology can be found in various fields such as agriculture, democracy and governance, energy, climate and environment as well as health and philanthropy (Galen et al., 2018). In those cases, tokens are implemented to represent various things such as reputation, a sustainability score or knowledge, and not just money. Especially the following advantages of the blockchain technology have been used: (1) The ability of risk / fraud reduction as well as an increase in integrity, (2) higher efficiency, (3) enabling a process which was impossible before, (4) cost reduction or (5) creating bigger scales (Galen et al., 2018). For instance, due to the skyrocketing demand for organic food as well as the flood of corresponding labels, a transparent, non-editable, quick and low-cost labeling technique is required. Blockchains seem to be a highly feasible solution to monitor the supply chain of specifically labelled goods (Boldu & Fonds, 2018). The front end visible to users of these applications is called a DApp (distributed application). They constitute both the front end and the smart contracts, while the back end is distributed on several servers and not only on one centralized one as for usual apps.

When a DApp is created, next to the technical aspects, the incentive system underlying the smart contracts determines its acceptance in the community and, thus, long-term success. This incentive system is defined during a stage called Cryptoeconomic Design Phase. In this stage, the implications of the behavior in accordance to the “tragedy of the commons”, as proposed by Nobel prize winner Hardin, is managed (G. Hardin, 1968). This is typically done by setting up an efficient and effective incentive system, which optimally results in reasoned, smart and future-oriented token designs. It can be differentiated into one and multi-token systems, as we will use a two-token system in our proposed model.

In the case of the Romanian Carpathians, some locals exploit and thus partly destroy the valuable natural habitat for personal, non-sustainable gains. Thus, the aim of the Cryptoeconomic Design

Phase is to provide gatherers and hunters with enough short and long-term incentives, so that eventually their interests are aligned with the sustainability goals of WWF.

One development opportunity for local communities nearby intact ecosystems is ecotourism, which is also supported by WWF and described as one of the few viable options. Ecotourism is “responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education” as described by the International Ecotourism Society (TIES, 2019), and highlighted by WWF (WWF, 2019). The role of this community-based ecotourism is to support the goals of WWF by (1) improving the livelihood of local communities, (2) encouraging communities to be more directly involved in conservation and (3) create a better symbiosis between the local community and protected areas (WWF, 2001).

3. Model Proposal

Overview

We propose a new model to preserve nature, empower communities and grow local economies in a sustainable way. It uses money from donors and investors as a starting point but aims at being fully self-funded and self-governed after a certain period of time. Recent developments in the area of technology, especially blockchain and smart contracts, are leveraged to make the flow of money transparent and to allow tamper-proof access to information about the health of the environment to all parties involved as well as to the general public. We believe preservation of nature is a multi-facetted challenge which also needs to address socio-economic wellbeing such as unemployment and the lack of resources and education. The proposed model creates new employment possibilities, provides training for new jobs and furthermore creates a framework for local business initiatives and entrepreneurship to thrive. Thereby the model lays the foundations for a sustainable growth of local economies and the increase of socio-economic wellbeing while preserving nature continuously and long-term without further need for lasting donations or the governing by a single authoritative body.

Architecture

The proposed model is centred around a rate-limited ecotourism as a sustainable revenue stream to fund all costs related to the preservation of nature and the development of local communities. With the exception of the initial funding provided by donors and investors, the model aims at being self-reliant and independent of any single governing body. A blockchain backbone is used to foster trust, distribute decision making and make all flows of money and information about the ecosystem transparent, tamper-proof and easily available. Smart contracts ensure the right incentives are in place, automate processes and limit the potential for abuse by any single party.
Figure 1 gives an overview of the inner links of the proposed model. On the following pages, detailed descriptions of all the involved parties and the blockchain backbone can be found.

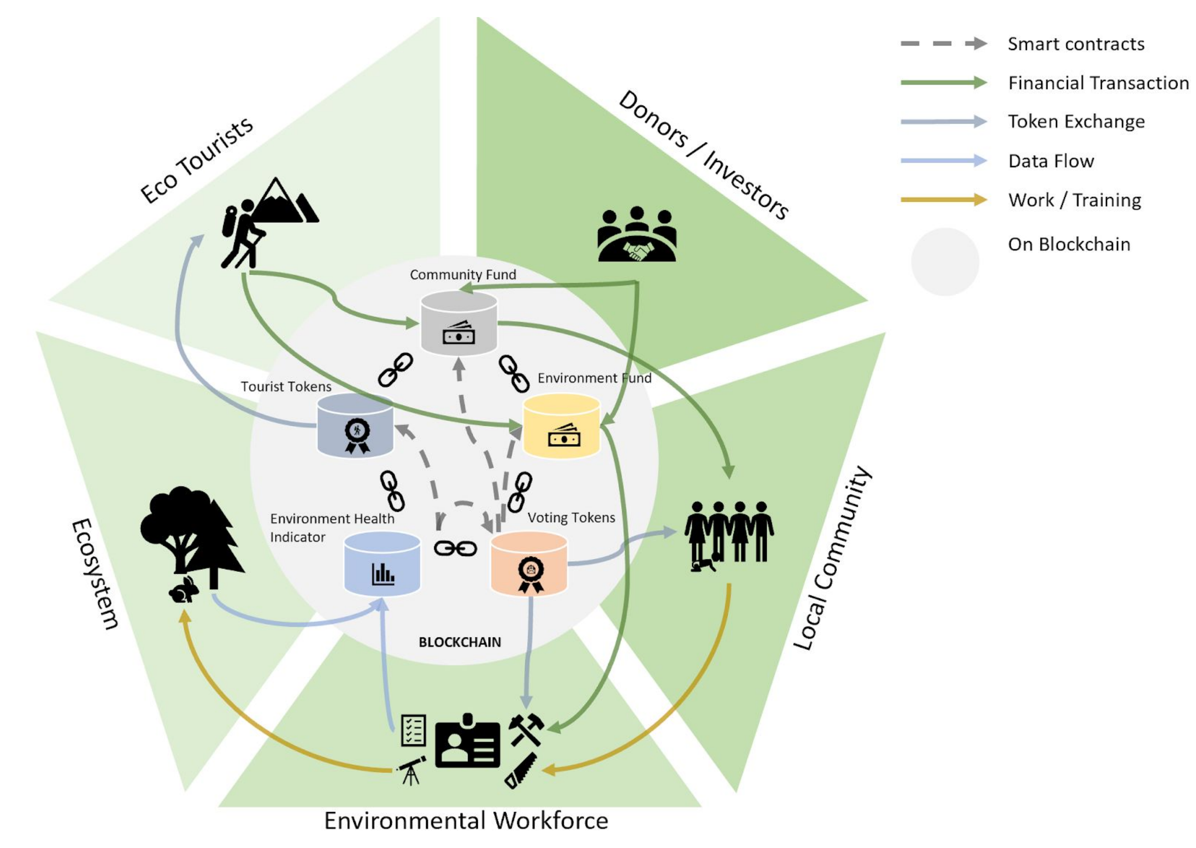


Figure 1: Involved parties and flow of money, tokens and information for the proposed model.

Components: Involved Parties

Donors / Investors

Initial funding is provided by donors and split between the "Environmental Fund" and the "Community Fund" according to the preference of the donor (main focus protecting the environment vs. community development / foreign aid). Because funds are transferred on the blockchain, all money can be transparently tracked and donors and investors can make sure that it reaches the desired destination. Furthermore, donors and investors get access to tamper-proof information about the impact their funds have had. This empowers donors and investors in a new way and creates new incentives for the funds to be used as effectively as possible.

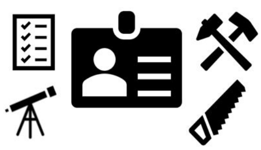
Ecotourists

Ecotourists wanting to visit the ecosystem must buy a “Tourist Token” for a specific time period, e.g. one week. Depending on the health of the ecosystem more or less Tourist Tokens are available, which is automatically enforced by smart contracts based on the data collected by independent sensors or by data hunters and gatherers. If the demand for Tourist Tokens exceeds the supply, prices raise automatically, thereby increasing revenue while keeping the numbers of tourists at a constant and sustainable level. Since tokens are linked to the blockchain, the risk of fake or tampered Tourist Tokens is negligible.

Ecosystem

We refer to the environment to be preserved generally as the “Ecosystem” in this model. Interference into the Ecosystem is kept to a necessary minimum for preservation purposes and the ecotourism. All work done within or directly related to the Ecosystem is carried out by the “Environmental Workforce”. Tasks include building and maintaining hiking trails, admission control into the Ecosystem (only tourists with a currently valid Tourist Token are allowed in), reforestation, rewildings and monitoring of the health status of the Ecosystem. Additional information about the wellbeing of the Ecosystem is gathered automatically, e.g. by zero-emission drones or distributed sensors. Satellite data can eventually be used as well to track deforestation. All information about the health of the Ecosystem is fed into the blockchain and made available to all parties involved. Additionally, a real-time dashboard accessible to the general public can be imagined.

Environmental Workforce

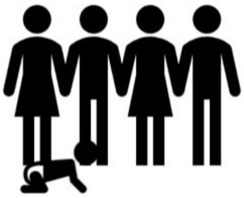


The Environmental Workforce is recruited from the “Local Community” and trained with means from the Community Fund while the actual salary stems from the Environmental Fund. Several ways of employment are possible: full time, occasional freelance work, and others.

People working in the Environmental Workforce can earn Voting Tokens for performing positive actions for the Ecosystem. With Voting Tokens one can decide where funds from the Environmental Fund and Community

Fund are used, thereby directly empowering the locals involved and decentralising decision making.

Local Community & Local Businesses



The Local Community consists of the people already living in the area of interest. The model proposed in this paper aims at improving quality of life, education, job security and the formation of a framework for the creation and growth of locally owned businesses. While changes to the landscape within the Ecosystem are kept to the bare minimum necessary for the ecotourism, the Local Communities are free to provide further services for the ecotourists within their own municipalities, thereby boosting the local economies and increasing wealth.
Funds from the Community Fund are directly used for projects within the Local Communities, e.g. for infrastructure or for job trainings to become part of the Environmental Workforce. This will allow the proposed model to be used in a more development / foreign aid oriented setting, too.

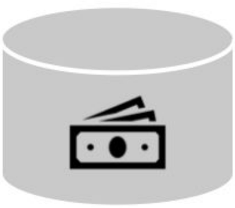
Components: The Blockchain Backbone

All flows of money, information, tokens and voting decisions are made on the blockchain, thereby providing a tamper-proof, trustworthy and transparent backbone to the model for everyone involved.

Environmental Fund

The Environmental Fund provides the money to maintain all work necessary within the Ecosystem: Reforestation, rewildings, infrastructure for the ecotourism and gathering of Environmental Health Indicators. The Environmental Workforce is therefore paid entirely through the Environmental Fund. The money stems from donors and investors initially, at a later stage income from the selling of Tourist Tokens is used.
How the money is spent is decided decentrally by the owners of Voting Tokens, i.e. amongst others by current and former members of the Environmental Workforce.

Community Fund



Like the Environmental Fund the Community Fund is initially fed by donors and investors and, as the local ecotourism economy grows, after a while solely by the revenue generated by selling Tourist Tokens. The money in the Community Fund is used for projects in the local community, e.g. training of people for the Environmental Workforce and sustainable infrastructure projects.

The availability of funds for local non-ecosystem related projects is governed by smart contracts which use the Environmental Health Indicators to estimate the wellbeing of the Ecosystem, i.e. the better the Ecosystem is doing the more funds are available to be used within the Local Communities. This creates an incentive to the Local Communities to keep the Ecosystem as healthy and as intact as possible. As for the Environmental Fund, the allocation of money is decided decentrally by the owners of Voting Tokens.

Voting Token Pool

The Voting Token Pool contains tokens which are handed to workers in the Environmental Workforce for carrying out the respective positive actions. The voting tokens allow their owners to decide on the usage of the money in the Environmental Fund as well as in the Community Fund. To disallow misuse of the money, all transactions are made on a blockchain with complete traceability. Furthermore, smart contracts limit the range of options the money can be spent on.

To involve people over a long period of time as well as having an incentive to be an active member of the Environmental Workforce, the voting power attached to each token decreases over time and reaches zero after a certain amount of time, e.g. ten years.

One could consider distributing a single Voting Token to every member of the Local Community and not just to the Environmental Workforce. This might increase involvement and acceptance while still keeping up the incentive to participate actively, since then more Voting Tokens could be earned.

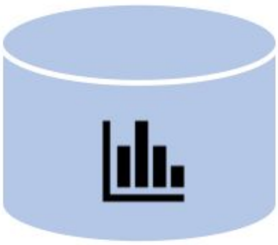
Tourist Token Pool

Tourist Tokens can be bought by Ecotourists and allow the entrance to the Ecosystem for a certain amount of time, e.g. one week.

The Tourist Tokens have several purposes. They effectively limit the number of tourists to what is believed to be a sustainable level, they work as a kind of entrance fee or tourist tax which provides the means for the Environmental Fund as well as for the Community Fund. Last but not least they incorporate an automatic price adjustment algorithm; the higher the demand for the Tourist Tokens the higher the prices and therefore the higher the income for the two funds.

Smart contracts are in place which use the Environmental Health Indicators to determine the amount of Tourist Tokens available. I.e. if the Environmental Health Indicators show that the Ecosystem is doing worse, the number of available Tourist Tokens automatically decreases. This has two major effects: First, less Ecotourists enter the Ecosystem, therefore decreasing their impact on nature. Second, it is an incentive for the local community profiting from tourism to do everything in their power to keep the Ecosystem healthy.

Environmental Health Indicators



Constant measurements about the health of the Ecosystems are taken. One part is done manually by the Environmental Workforce, e.g. through inspections of certain areas, while the rest is done more or less automatically by means of chipped animals, zero-emission drones and distributed sensors.

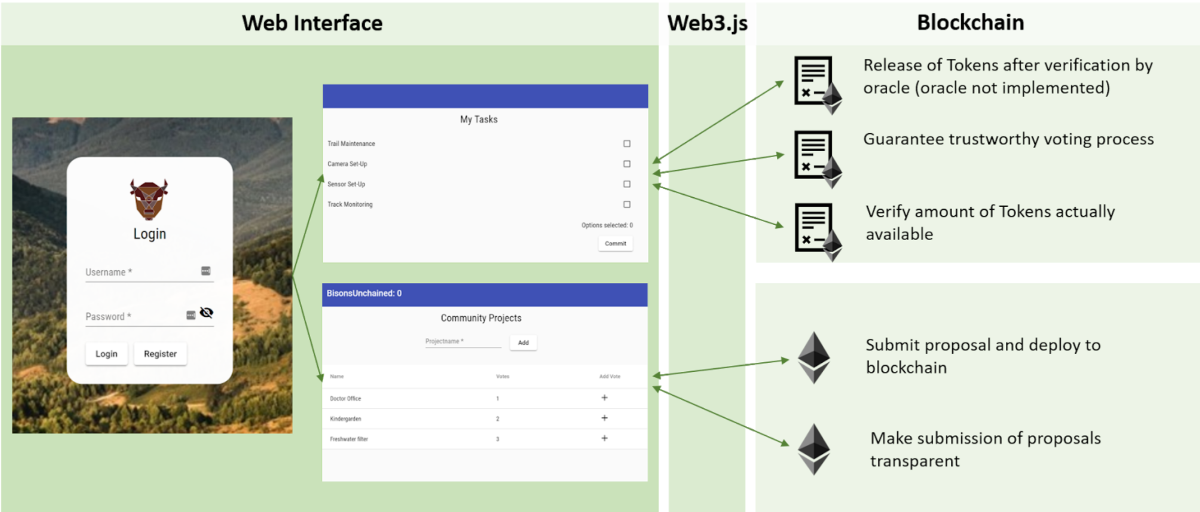
All measurements are fed into the blockchain and are made available to all stakeholders: the general public, Ecotourists, donors and investors, the government and the Local Communities.

The Environmental Health Indicators are used as the basis for most smart contracts in the proposed model. Only if the indicators attest a healthy Ecosystem or if certain milestones are reached will Community Funds be available or will the number of Tourist Tokens stay at a high, yet sustainable level.

4. Technical Proof Of Principle: Voting System

While the model proposed in this paper has various aspects running on a blockchain backbone, we decided to do a proof of principle with one selected part: the interaction of the Environmental Workforce with the blockchain with regards to task completion, earning tokens, proposing and voting on community projects and spending of the Community Funds.

Our software consists of three different parts: 1. the website / UI for the Environmental Workforce, 2. the code directly related to the blockchain written in Solidity and 3. Web3.js as link between the two.



The UI For The Environmental Workforce: The Website

The Website is built with Angular. It consists of three modules: A login page, a page where the community members can vote on projects and submit their own ideas, and a page where community members can earn tokens by confirming that they have completed various tasks. Currently, the login page only accepts two different accounts: username: hunter, password: hunter and username: hunter2, password: hunter2. However, this does not actually make an important difference since our interactions with the blockchain are currently managed over the accounts in MetaMask. Furthermore, the login process is not secure and can easily be circumvented, also the register function is not yet implemented. One of the next step would be to fix the just mentioned issues and bind the accounts to a private and public key to interact directly with the Blockchain.

After logging in you will be redirected to the Tasks page. On this page the front end user can see what kind of tasks he can do and gain Voting Tokens for. You are able to select the ones you have completed and send this information to the blockchain. You can also switch to the projects page. There you can submit new projects on which the community can vote and vote on existing projects with the earned Voting Tokens.

The Link To The Blockchain: Web3.js

We use Web3.js (version 1.0.0, beta 37) in combination with the MetaMask extension for the browser to communicate with our contracts on the blockchain. Web3.js is a powerful JavaScript library capable of interacting with the Ethereum Blockchain, especially doing transactions on the blockchain, managing accounts and, in our case, communicating with a contract and using its methods. MetaMask allows us to connect to a blockchain-network and conduct transactions requested by our Web3.js functions.

It is a mandatory requirement, for these functions to work that a smart contract is deployed. More on this in the next section. Once done, the address of the block the contract is deployed on and the ABI[1] are required to create a contract object and establish a connection. This object then allows us to send or receive data. On one hand, we need to send data whenever the user wants to complete a task and receive the tokens, vote for a project or suggest a new project to be voted on. On the other hand, we need to receive data in order to display all projects currently proposed and to show the account balance to the user. For each of these requirements we create functions due to which the website can access the smart contract. This allows a relatively independent development of both the front and the back end.

Smart Contracts On The Blockchain

We programmed our token and voting system in Solidity (0.4.22 <= Version < 0.6.0) and used the Rinkeby network in order to run and test our project.

The blockchain-centered part of the code is responsible for implementing the fundamental idea of using tokens the way they were described in the previous chapters. Given the limited amount of time available, we chose to only implement the Voting Token Pool in a simplified way. Technical standards to implement tokens for smart contracts on the Ethereum blockchain already exist, like ERC-20 and ERC-721 to name just two. However, we decided against this approach in favor of being able to implement a handful of small functions in a short time with the aim to demonstrate the concept. Consequently, we lost the ability to inject a state into the tokens as they became fungible. Further, ideas such as decreasing the values of a single token over time or setting some kind of expiration date had to be neglected.

Our voting system in Solidity consists of two contracts: a Voting and a ProposalFactory contract. A person working in the Environmental Workforce is called a “Voter” in our contract and has a countVote field which holds the amount of tokens that the worker has previously received. The Voting contract handles all the logic concerning the voter, e.g. incrementing the countVote field by a specific amount if

[1] Application Binary Interface, a JSON array containing all methods and variables of a smart contract

that worker has earned tokens. To decide how many tokens have been provided for each task, there is an assignment list which can be modified externally. The other necessary contract was the ProposalFactory contract which is about the proposed projects of the Local Community. The creation as well as how to handle the end of a voting is implemented in this contract. We added an additional function which allows to look for an existing project and see the current status of the number of votes it received.

As mentioned throughout the comments in the actual code itself, it is important to keep in mind that the main focus is to provide a mere taste of one possible approach to implement such a token pool. Nevertheless, we think that a future implementation could extend this code to support more realistic requirements by replacing dummy values and adding further functionalities.

We will briefly discuss two options to improve our code, once with respect to cost efficiency and once with respect to security. Firstly, the functions could be modified such that they are classified as being "external" (can only be called from outside of the contract) and "view" (does not change any variables within the contract). The contracts in Solidity which have these specifications are more cost efficient because there will not be any transaction initiated which would cost gas (the transaction fee one has to pay). Secondly, the security of the code is also a point for discussion: what is a worker allowed to do and where are the potential "bugs" or exploitation possibilities in our code? One thing that we did implement is to check whether the voter is illicitly giving out more Vote Tokens to a proposal than he owns. Another additional option would be if we limit the number of times a worker can vote with his tokens in a specific time span. It would prevent a spam of tokens flooding into the system in a short amount of time. We also need to ensure that the workers' motivation to submit too many proposals is kept small. That is why we restricted it by putting a proposal fee in case someone would want to create one.

5. Implementation & Discussion

Implementation

Our model is building upon and extending the concept, WILD AI, proposed by WWF. Therefore, the obvious choice for selecting a small-scale test ground would be an area or community where the latter has already been introduced, first experiences have been made and where the people have gained trust in the system. Ideally, the local community has already started offering small scale, niche tourism. With the insights and the experience of the test, the concept can be refined and expanded to other regions, as it is planned by WWF for the Amazonian forest.

Discussion

Designing a well-running and accepted incentive system is a delicate act of balancing interests and motivations of many stakeholders. In such complex systems it is difficult to predict how people in the actual world will act. One of the most critical aspects of the model proposed is how to correctly incentivize the local communities to use the system and to encourage long-term and sustainable thinking so that the well-being of the environment is secured and permanently linked to the well-being of the community. This is also why in general the Cryptoeconomic Design is of such great importance. The concept needs to be tested, and continuously refined and adjusted. Another aspect that needs to be evaluated is that one solution will likely not fit all purposes. What works in one community might not work for a neighboring community. Therefore, the concept should leave room for flexibility to adjust to local needs.

The number of tourists respectively the number of available Tourist Token is a critical parameter that needs to be carefully determined and calibrated according to the capacity of the nature reserve to ensure economic, social and ecological sustainability.

6. Conclusion/Outlook

The proposed model leverages blockchain technologies to find a balance between socio-economic needs of local communities and environmental protection. While the model aims to address the most fundamental challenges such as distribution of funds and incentives to protect the ecosystem, many in practice highly relevant details were not addressed. One example is the legal system in which the model is embedded and which needs to be taken into account in order to ensure operation within its boundaries and general acceptance. Also, payment for wages and goods needs some kind of legal structure which, ideally, is not controlled by a single party. Furthermore, we used the blockchain for all transfers of money and indicators about the health of the ecosystem. While in theory this has valuable advantages such as traceability, trust and transparency, in practice it might slow down the entire system, incur transaction costs and, depending on the blockchain technology used, lead to a large energy consumption. Especially the latter would contradict a model aiming at conserving the environment. The further development of the blockchain technology needs to be closely watched in order to see whether novel and less energy intensive ideas such as proof of stake will gain general acceptance.

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