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**Евсеев А.В.,**
**Красовская Т.М.,**
**Тикунов В.С.,**
**Тикунова И.Н.**
Московский государственный университет им. М.В. Ломоносова,
географический факультет,
кафедра рационального природопользования,
г. Москва, Россия

# УРЕГУЛИРОВАНИЕ КОНФЛИКТОВ В ОБЛАСТИ ЗЕМЛЕПОЛЬЗОВАНИЯ НА ЗЕМЛЯХ КОРЕННЫХ НАРОДОВ НА ОСНОВЕ БЛОКЧЕЙН-ПЛАТФОРМЫ НА ПРИМЕРЕ РОССИЙСКОЙ АРКТИКИ

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Вступление. Территории традиционного природопользования (ТППП) коренного населения относятся к числу наиболее уязвимых к природопользовательским конфликтам различного происхождения: социально-экономическим, экологическим, институциональным. Эти риски связаны с грядущими изменениями практики природопользования в пределах 8 зон опережающего развития, предусмотренных недавно принятой Стратегией социально-экономического развития Российской Арктики до 2035 года.

Материалы и методы исследования. Исследование основано на недавно опубликованных социально-экономических, экологических, экологических статистических и пространственных данных, полевом опыте в регионе, а также на совместных международных проектах с RAIPON. Теоретические основы работы базируются на нескольких концепциях построения блокчейна ВЭФ, подходах к системному анализу в экологии и эколого-экономических базовых концепциях.

Результаты исследований и их обсуждение. Возникновение конфликтов природопользования, как правило, связано с чрезмерной эксплуатацией пулов регулирующих и обеспечивающих экосистемных услуг. Федеральное законодательство гарантирует права коренных малочисленных народов, но для их защиты необходимо учитывать различные данные. Подобные данные необходимы им для управления TTNU с учетом современных климатических изменений. Эта информация необходима для содействия адаптивному региональному развитию, полезному для региональной устойчивости. В настоящее время региональные наборы данных централизованы, часто не обновляются вовремя, и их нелегко получить. Блокчейн-структура может быть полезна, чтобы из-

бежать таких препятствий, особенно когда определенная база данных будет использоваться для записи операционных процессов и текущих изменений в землепользовании, связанных с их новыми моделями и изменением климата. Разработана модель блокчейн-транзакций для природопользования в ТТНУ. Были проанализированы данные о возможных переходах земного покрова и их результаты в ТТНУ. Были определены пользователи блокчейна и описаны необходимые наборы данных. Технологии блокчейна оказались полезными во многих сферах экономической деятельности. Представленная здесь структура блокчейна отличается от «исключительно экологического» направления использования блокчейна. Междисциплинарное решение включает в себя информацию о специфических факторах «бунта» в панархических социально-экологических системах природопользования (когда быстрые, мелкие события подавляют большие, медленные). Эта информация часто связана с развитием производственной и транспортной инфраструктуры и должна учитываться для обеспечения устойчивости коренного населения, проживающего на территориях опережающего экономического освоения, а также демонстрировать риски для ТТП, связанные с изменением климата и другими опасными природными явлениями.

Выводы. Технология блокчейн характеризует четвертую промышленную революцию, отвечающую вызовам настоящего и будущего. К преимуществам использования блокчейн-подхода в ТТНУ можно отнести следующее:

— обеспечение многофункциональной платформы, необходимой для обеспечения интересов многих заинтересованных сторон.

— формирование баз данных для практики территориального и местного (в пределах ТТП) планирования, способствующего устойчивому развитию и адаптации к современным изменениям климата.

— поддержка независимого хранения временно-пространственных данных и их постоянное обновление, доступное для коренных общин (и других заинтересованных сторон).

— предоставление новых данных, необходимых для прогнозирования природопользования конфликтов в ТТНУ.

Представленное здесь блокчейн-решение может способствовать устойчивой модели экономического развития Арктической зоны в отношении благосостояния коренного населения и обеспечения оптимального использования его его природного капитала посредством государственного и частного сотрудничества.

Ключевые слова: блокчейн; Арктика; коренные народы; конфликты.

**Evseev A.V.,** Lomonosov Moscow State University, Faculty of Geography, Rational Nature management department, Moscow, Russia
**Krasovskaya T.M.,** Lomonosov Moscow State University, Faculty of Geography, World Physical Geography and Geoecology department, Moscow, Russia
**Tikunov V.S.,** Lomonosov Moscow State University, Faculty of Geography, World Data Center for Geography, Moscow, Russia
**Tikunova I.N.** Lomonosov Moscow State University, Faculty of Geography, Geography of World Economy department, Moscow, Russia

# Regulation of land use conflicts at indigenous peoples lands based on blockchain platform, russian arctic case study

Introduction. Territories of traditional nature use (TTNU) of indigenous population are among the most vulnerable to nature management conflicts of different origin: socioeconomic, ecological, institutional. These risks are connected with future changes of nature management practices within the 8 advanced development zones foreseen by the recently adopted Strategy of socioeconomic development of the Russian Arctic till 2035.This document mentions indigenous population rights in the course of the planned land use changes. Nevertheless, indigenous communities may be involved in land use conflicts at TTNU because of the overlapping by new land use patterns of new stakeholders. Another problem concerns land use adaptation to modern climate change. Accumulation of appropriate information for indigenous communities' decision making is very often a difficult process: it is very diverse and scattered. Modern approaches to database composition enable to elaborate a statistical, institutional and spatial data platform for information support of territorial planning procedures at TTNU, especially helpful for indigenous communities living at remoted territories. The goal of this investigation is the elaboration of a multi-functional information platform based on blockchain principles needed to achieve adaptive development of TTNU involved in the process of land use patterns transformation. Blockchain methodology helps to arrange the accumulated data connected with nature management practice and receive a new knowledge for practical use and scientific research development independent from stakeholders lobby groups.

Study area. The study area includes territories of the 8 advanced development zones in the Russian Arctic with Saami, Komi-Izma, Nenets, Enets, Nganasan, Sel'kups, Evenk, Reindeer Yakut, Cuckchi, Dolgans population living there. It is about 3,2% from the region's population. Up to 25% of the indigenous population is occupied in traditional

economy. The study area is situated in the Subarctic and Arctic geographical zones with severe climatic conditions. The dominant environment includes tundra of different types and forest-tundra with rare patches of northern taiga at the southern limit. The geological and tectonic structure of the territory provokes a possibility of earthquakes. Permafrost disruptions are typical. It is stimulated by climatic warming which also causes a risk of radical changes in traditional occupations :loss of hunting and fishing resources, reindeer pastures productivity, etc. Changes of ecological situation may be mainly connected with modern air and water pollution in industrial impact zones and mechanical disruptions. This diverse information is needed for adaptive spatial planning procedures at TTNU to follow the principles of sustainable development disclosed by the Arctic Council documents.

Materials and methods. The investigation is based on the recently published socioeconomic, environmental, ecological statistical and spatial data, field experience in the region as well as in joint international projects with RAIPON. The theoretical fundamentals of the work are based on several concepts of WEF blockchain building, approaches to system analysis in ecology and ecological-economic basic concepts.

Results. The origin of nature management conflicts, is usually connected with an excessive exploitation of regulation and provisioning ecosystem services' pools. Patterns of such conflicts were presented. Rare are relevant remarks concerning information (spiritual) ecosystem services supporting social cohesion, cultural traditions, sense of place, etc., important for indigenous communities to preserve their identities. This topic was discussed separately. The Federal legislation guarantees the rights of indigenous communities, but to protect themselves they need to consider various data. Similar data is necessary for them to manage TTNU, regarding present climatic changes. This information is necessary to promote adaptive regional development beneficial for regional sustainability. The procedure of conflict detection and forecast for a certain territory is based on separate data sets analysis by independent stakeholders. But nowadays regional data sets are centralized, often not updated in time, not easy to reach. Blockchain structure may be useful to avoid such obstacles, especially when a certain database will be used to record operational processes and ongoing changes in land use connected with their new patterns and climate change. Blockchain methodology may be used to elaborate a distributed register of large various data sets, including visualization of statistics, which may be very helpful for decision making by stakeholders at TTNU and reliable accounting of ongoing land use changes. Blockchain transaction model for nature management at TTNU was elaborated. Data on possible land cover transitions and their results at

TTNU were analyzed. Blockchain users were outlined and necessary datasets were described. The structure composition of the suggested model was connected with available information for sets saturation and may be enlarged in future. Obstacles in blockchain approach use at TTNU were discussed.

Discussion. Blockchain technologies proved to be useful in many spheres of economic activities. Examples of blockchain use in nature conservation practice, green energy development, pollution control, etc. were presented as well as blockchain technologies use to solve ecological problems highlighted by the Fourth World Economic Forum. The presented here blockchain structure corresponds to these challenges. But its structure at the same time it is different from the "entirely ecological" direction of blockchain use. Additional information is necessary for nature management, i.e. integrated data processing concerning economic, ecological, environmental, ethnic-cultural, etc. data. The proper nature management needs interdisciplinary solutions which are reflected in our assets structure. Interdisciplinary solution includes information about specific "revolt" factors in panarchy social-ecological nature management systems (when fast, small events overwhelm large, slow ones). This information is often connected with industrial and transport infrastructure development and should be considered to provide sustainability to indigenous population living at the territories of the advanced economic development as well as demonstrate risks to TTNU connected with climate change and other natural hazards.

Conclusion. Blockchain technology characterize the Fourth Industrial Revolution meeting the challenges of present and future time. The advantages of blockchain approach use at TTNU include the following:

— providing a multi-functional platform necessary to ensure multi-stakeholders' interests, indigenous communes being among them.
— arranging data bases for territorial and local (within TTNU) planning practice contributing to sustainable development and adaptation to modern climate change.
— supporting temporal-spatial data assets independent storage and their constant updating available for indigenous communities (and other stakeholders).
— supplying new data necessary to forecast nature management conflicts at TTNU.

Blockchain solution presented here may promote sustainable pattern of the Arctic zone pioneer economic development regarding indigenous population well-being and ensure optimal use of its nature capital via public-private collaboration.

Key words: blockchain; Arctic; indigenous peoples; conflicts.

## 1. Introduction

The modern economic development of the Russian Arctic zone is connected with a risk to provoke nature management conflicts of different origin: socioeconomic, ecological, institutional. Territories of traditional nature use (TTNU) of indigenous population are among the most vulnerable to such risks. Modern climatic changes in the Russian Arctic complicate the situation even more. These risks are connected with future changes of nature management practices within 8 advanced development zones foreseen by the recently adopted Strategy of socioeconomic development of the Russian Arctic till 2035. This document contains special references concerning observance of indigenous population rights in the course of the planned land use changes. Among the main goals– improvement of the life quality and protection of the Arctic zone population. Nevertheless, indigenous communities may be involved in land use conflicts at TTNU because of the expected process of overlapping by land use patterns of new stakeholders. Another problem concerns land use adaptation to modern climate change. Accumulation of appropriate information for indigenous communities' decision making is very often a difficult process: it is very diverse and scattered. It should be mentioned that the adopted economic development plans are subjects to public discussion at different levels, in which NGO and local populations are involved as well.

The realization of the adopted Strategy demanded centralized activities of many ministries and departments involved in this process: Ministries of Economy, Nature resources and Ecology, for the Development of the Far East and the Arctic, Transport, Energy, etc. These activities were declared in a special Government Resolution adopted in 2016. Their integrated diverse information provides mechanisms for the strategic plans' realization. In order to provide an access to this information the Federal Plan of Statistics Works in 2016 was completed by a special program devoted to the Arctic zone and the program implementation is underway.

Nowadays important for nature management available statistical data concerns mainly GRP economic parameters, meteorological monitoring data, exploitation characteristics connected mainly with mineral resources extraction. exploitation of the Northern Sea Route and trans-

port infrastructure development, etc. Statistical information concerning ecological, ethnological, nature capital regional assessments (excluding mineral and hydrocarbons resources), nature management patterns, culture issues is still inadequate and scatted. There are only few examples of system approach for this information presentation and visualization, which may be very helpful for Federal and local decision-makers, stakeholders, public organizations, etc. [National atlas of the Arctic, 2017, Ecological Atlas of Russia, 2017, The Laptev Sea, 2018, Evseev et al., 2019, Zamyatina, Goncharov, 2020, etc.]. Modern approaches to database composition enable to elaborate a statistical, institutional and spatial data platform for information support of territorial planning procedures at TTNU, especially helpful for indigenous communities living at remoted territories [Evseev et al., 2018]. The goal of this investigation is the elaboration of a multi-functional information platform based on blockchain principles needed to achieve adaptive development of TTNU involved in the process of land use patterns transformation connected with the planned socioeconomic development of the Russian Arctic zone. This is of vital importance to promote cooperation among stakeholders and prevent nature management conflicts at TTNU thus saving nature capital and indigenous communities in the changing modern World. Blockchain methodology helps to arrange the accumulated data connected with nature management practice and receive a new knowledge for practical use and scientific research development independent from stake holders lobby groups.

## 2. Study area

The study area includes territories of 8 advanced development zones in the Russian Arctic (fig. 1) with Saami, Komi-Izma, Nenets, Enets, Nganasan, Sel'kups, Evenk, Reindeer Yakut, Cuckchi, Dolgans etc. (17 indigenous peoples in total) living there. It is about 82 500 or 3,2% from the region's population [Tishkov.., et al., 2015]. 9–25 % of the indigenous population is occupied in traditional economy. Regional administrations have special departments dealing with indigenous population issues. Russian Association of Indigenous Peoples of the North (RAIPON) presents their central NGO. On economic reasons several parts of the ancestral territories of the indigenous population may be in-

volved in the planned economic development, mainly due to the Northern Sea Route infrastructure construction and renovation in Tiksi, Pevek, Amderma and other sea ports, new mineral resources and hydrocarbons extraction sites in Northern Yakutia, Taimyr-Turukhansk advanced development zones etc. (fig. 1).

The study area belongs to the Subarctic and Arctic geographical zones with severe climatic conditions, where the dominant environment includes tundra of different types and forest-tundra with rare patches of northern taiga at the southern limit. The geological and tectonic structure of the territory provokes a possibility of earthquakes. Permafrost disruptions changing the environment are actual nowadays but this process is variable in space. It is stimulated by climatic warming which also causes a risk of radical changes in hunting and fish resources, reindeer pastures productivity important for indigenous population. Changes of ecological situation may be mainly connected with modern air and water pollution in industrial impact zones and mechanical disruptions, they are also variable [Evseev et al., 2021]. They are broad and active, for example, in Taimyr-Turukhansk advanced development zone (see No. 6, fig. 1) and very local in Northern Yakutia advanced development zone (No. 7, fig. 1). Thus, quite diverse information is needed for adaptive spatial planning procedures at TTNU to follow the principles of sustainable development disclosed by the Arctic Council documents [Arctic – Including Good Practice Recommendations, 2018]. It is evident, that sooner or later environment transformation processes will seize the majority of TTNU. This stipulates the necessity of adaptive nature management elaboration supporting TTNU development. Their variants are still not clear now. Nevertheless, among them are: enlarging of nature reserves territories with different nature protection regimes, location of carbon capture polygons, sites for windfarms, etc. at TTNU. Traditional indigenous population knowledge provides practical activities to withstand many natural hazards, but they are not adequate for adaptive management at TTNU at the background of modern socioeconomic and ecological changes. Permanent processing of new reliable information is needed for decision making by indigenous communities and regional authorities.

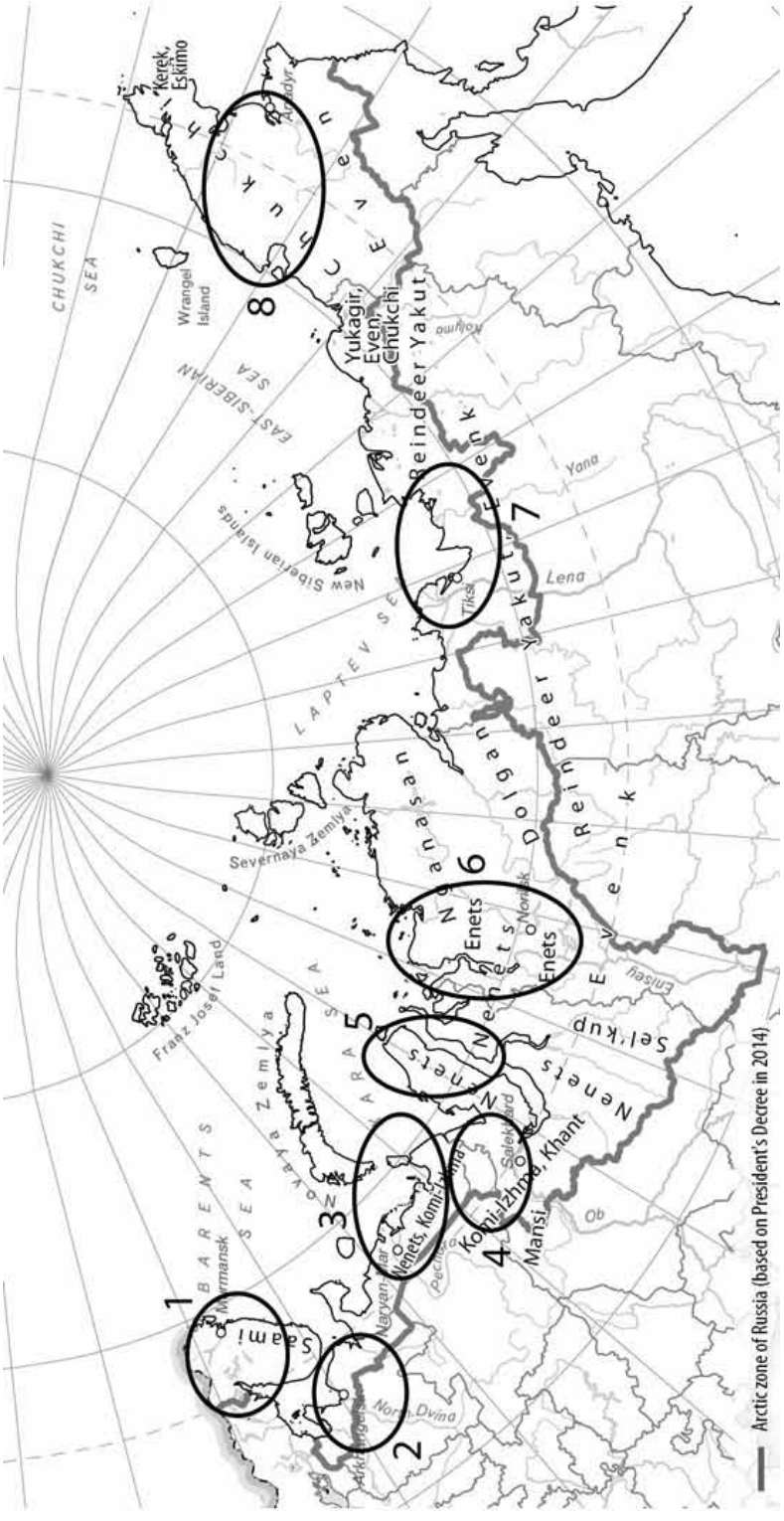


**Fig. 1.** Basic territories for the advanced economic development in the Russian Arctic at the background of indigenous populationterritories: 1-Kola, 2 - Archangelsk, 3 - Nenets, 4 - Vorkuta 5 - Yamal-Nenets, 6 - Taimyr-Turukhansk, 7 - Northern Yakutia, 8 - Chuckchi [Based on the Ministry of Economic Development documents, (2016)].

## 3. Materials and methods

The investigation is based on the recent socioeconomic, environmental, ecological statistical and spatial data [Rosstat, 2018, Nazional'ny atlas.., 2017, Ecologichesky atlas.., 2018, More Laptevyh, 2018, etc.], publications [official documents of the Russian Government, Evseev et al., 2018, 2019, Tishkov et al., 2020, etc.] as well as field experience in the region and experiences in joint international projects with RAIPON. The theoretical fundamentals of the work are based on several concepts of WEF blockchain building [Building.., 2018], ECORA Program, 2009, practical achievements in blockchain technology use in ecological projects [Building Blockchains for a Better Planet, 2018, DAO IPCI, 2017, Stefanović M., et al., 2018, etc.], approaches to system analysis in ecology [Gvishiany, et al., 2019, Odum and Odum, 2000] and ecological-economic basic concepts [Costanza et al., 2014, Dixon et al., 1994, De Groot et al., 2002, etc.].

## 4. Results

### 4.1. Nature capital transformation at TTNU and competition for exploitation of ecosystem services

Land use changes within the limits of the advanced development zones are mainly connected with overlapping of its new types, mostly often- industrial, transport and TTNU. This phenomenon means joint exploitation of different ecosystems services (see details below) at a limited space, competition for their use, thus provoking land-use conflicts [De Groot et al., 2002, Evseev et al., 2018]. At TTNU they are not only economic, but ethnic-ecological and ethnic-cultural as well. TTNU are territories preserving indigenous population culture and traditions, but not only productive territories for indigenous communities. It is necessary to mention climatic changes (up to the forecasted $6^0$C warming for some regions) as another important factor leading to natural capital transformation (mainly biological resources) followed by induced changes at TTNU [Climate change, 2009, Tishkov et al., 2020, etc.]. The origin of nature management conflicts, is usually connected with an excessive exploitation of regulation and provisioning ecosystem services pools, thus destroying regional nature capital [GEO5, 2012]. Rare are remarks concerning information (spiritual) ecosystem services supporting social cohesion, cultural tra-

ditions, sense of place, which are important for indigenous communities to preserve their identities. The Federal legislation guarantees the rights of indigenous communities, but to protect themselves they need to consider various data. Similar data is necessary for them to manage TTNU in an optimal way regarding present climatic changes. The same is needed for other stakeholders as well to promote adaptive regional development beneficial for regional sustainability.

### 4.2. Diversity of information for spatial planning procedures

TTNU nowadays experience many changes connected with both technological modernization of traditional activities and overlapping by industrial/transport land use. Our previous research [Evseev et al., 2018, 2019] showed that in case of overlapping of different stakeholders' lands various conflicts, based on ecosystem services joint exploitation, were possible (fig. 2). Most often regulating and provisioning ecosystem services were at the core of such conflicts.

The map demonstrates the diversity of different information needed to prevent land use conflicts and provide an adequate nature management. Sustainable economic development in the Arctic region is based on balancing of different stakeholders' activities concerning nature capital.

### 4.3. Blockchain technology use to avoid nature management / land use conflicts at TTNU

The procedure of conflict detection and forecast for a certain territory is based on separate data sets analysis by independent stakeholders. But nowadays regional data sets are centralized, often not updated in time, not easy to reach. Blockchain structure may be useful to avoid such obstacles, especially when a certain database will be used to record operational processes and ongoing changes in land use connected with their new patterns and climate change. The development of a mathematical model of a decentralized, large-scale protected array of data and infrastructure will increase the level of security and simplify the process of remote processing of documents, which may transform the way of nature management, eliminating the hidden conflicts and nature management inefficiency.

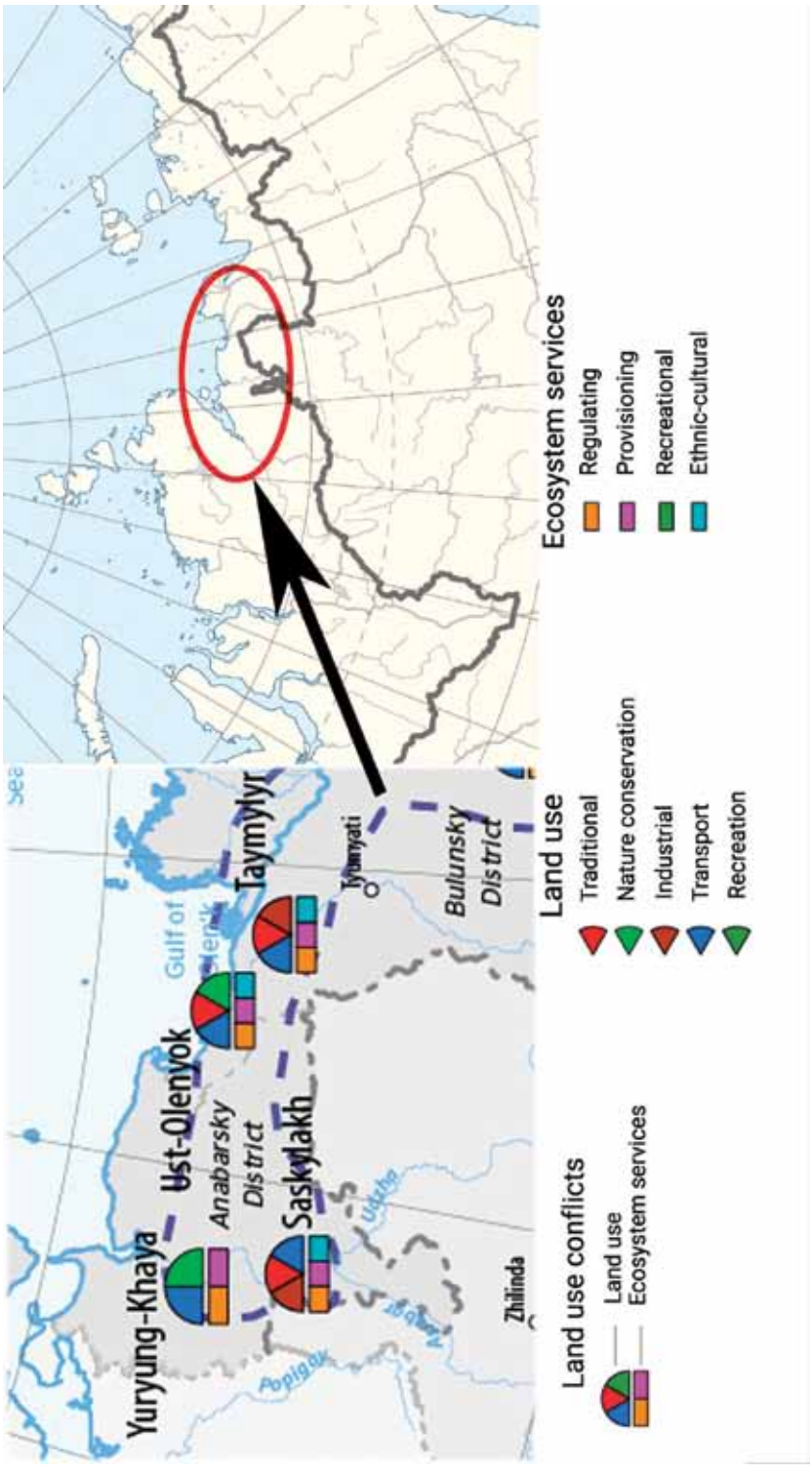


**Fig. 2.** Forecast of possible land use conflicts based on ecosystem services exploitation analysis for the Northern Yakutia **(No 7 at Fig.1).**

In 2018 the World Economic Forum Summit in California identified more than 65 ways blockchain approaches to the world's most-pressing environmental challenges and marked their advantages in the development of the technology that may fundamentally transform the way the world manages its natural resources [Building.., 2018]. This technology enables to create a decentralized electronic ledger system that record any transaction with nature capital at TTNU and make them transparent for different stakeholders.

Nowadays under the auspices of the Federal program "Digital Economy of Russia until 2025", adopted in 2017, more and more central and even individual campsites in the Arctic region receive satellite communication antennas. This enables local communities to use distant data bases. Blockchain technologies are promising to solve many problems of excessive management centralization limiting possibilities for indigenous communities to adapt to modern socioeconomic and ecological changes. Blockchain methodology may be used to elaborate a distributed register of large various data sets, including visualization of statistics, which may be very helpful for decision making by stakeholders at TTNU and reliable accounting of ongoing land use changes. Nowadays blockchain methodology is being implemented in the Federal cadaster service ("Rosreestr") in Russia. Similar activities exist in Germany ,India, Serbia, etc. [Gundelsweileri et al., 2007, Oprunenco, Akmeemana, 2018, Stefanovićet al., 2018, etc.].

### 4.4. Information blocks arrangement

According to the main concept, concerning the sustainable development of the Arctic indigenous population adopted in ECORA Project (ECORA, 2009), approaches of the SDWG [Good practices…, 2019, Sustainable development Working Group] of the Arctic Council [Arctic Council, 2019] 4 principle groups of factors should be considered in environmental management plans:

— environment (natural) factors;
— interference of economic structures;
— bi-cultural development (neo-traditionalism);
— institutional.

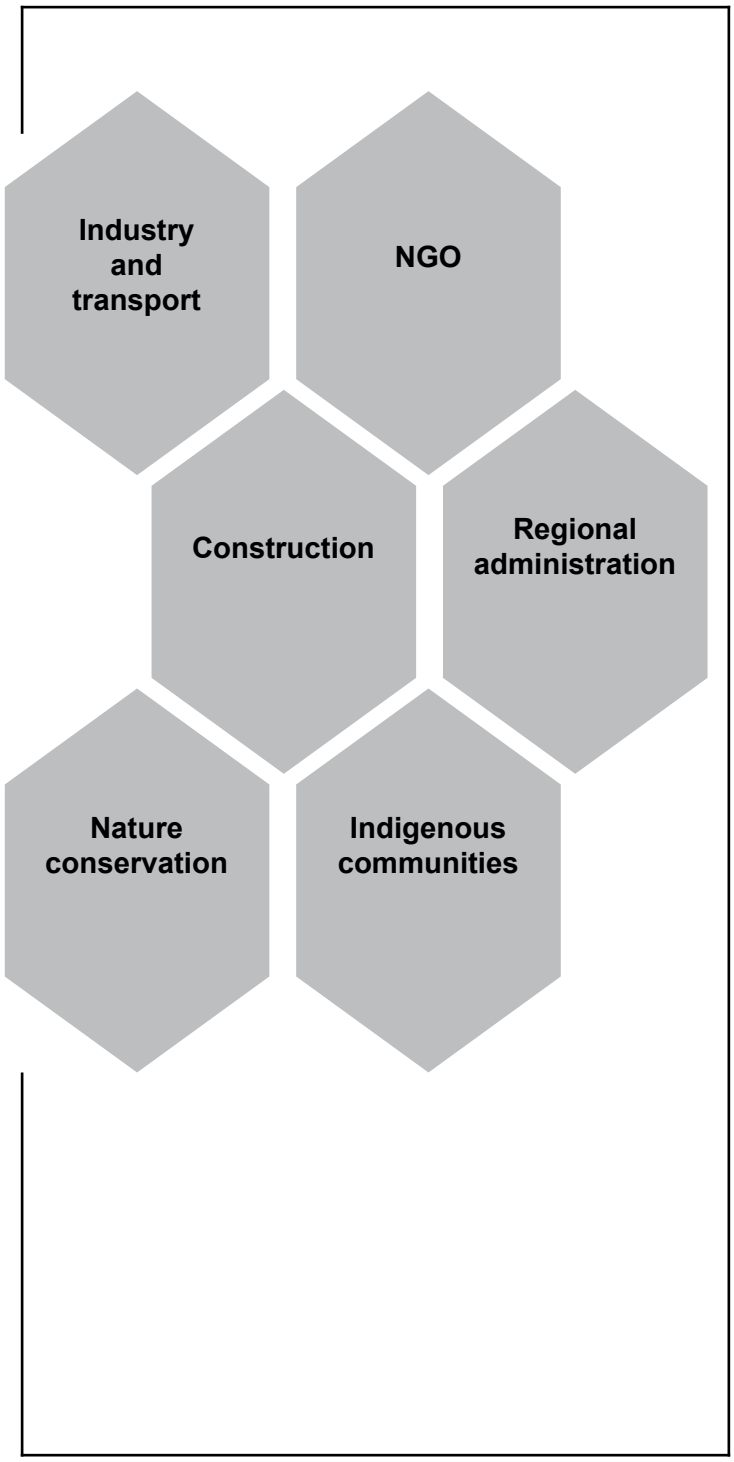


**Fig. 3.** **Blockchain users.**

We added another factor – ecological regarding the present ecological situation at the indigenous population lands and active climate change in several regions. We also expanded consideration of ECORA factors by changing the neo-traditionalism group by ethnic-cultural. Typical independent users and possible composition of blockchain data sets for the study area are presented in Figures 3 and 4. It must be mentioned, that data sets composition presents only the common view and maybe enlarged regionally especially for the environment, ecological and ethnic-cultural sets. Independent users may include not only stakeholders, but public organizations: indigenous, ecological etc.

As far as data sets composition is concerned only generalized data titles are given. Further details are described below.

#### 4.4.1. Environment (nature) assets

These assets include general regional information relevant to temporal and spatial features of nature background for economic development. Environment (natural) factors include those which may create obstacles/risks for economic development and should be taken into account. The most often risks for the studied region are the following: nature disasters (earthquakes, windstorms, etc.), rapid air temperatures rise connected with climatic warming, permafrost instability. It is also necessary to consider land cover type (tundra, forest-tundra, taiga forests, bogs, etc.) which determinates available for exploitation ecosystem services pools, day-light duration, climate comfort index, mean summer/winter temperatures, average wind speed, snow cover depth, etc. which are important for nature management practices. Some of these assets include issues which are regarded in traditional economy at TTNU due to traditional knowledge, but often ignored by new stakeholders. Ranking of the most possible obstacles/risks may be provided [Evseev et al., 2019].

#### 4.4.2. Economic assets

Temporal-spatial data presents modern state of economic development, the role of indigenous economy in GRP, land use structure, its spatial and functional changes (fig. 5), existing and possible competitive relations of different stakeholders for natural (biological, water) resources and ecosystem services exploitation, available and needed

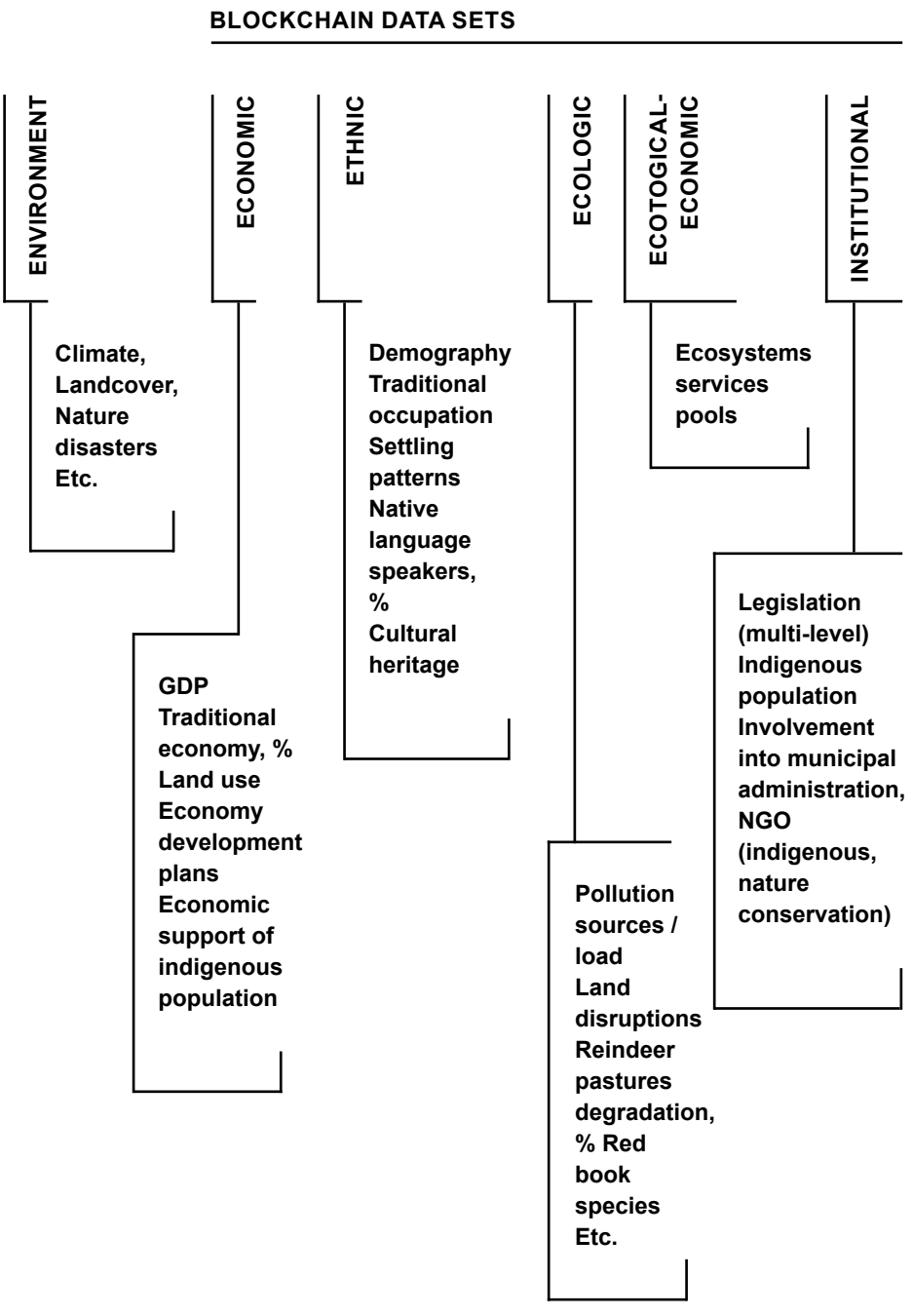


**Fig. 4.** **Blockchain datasets (assets).**

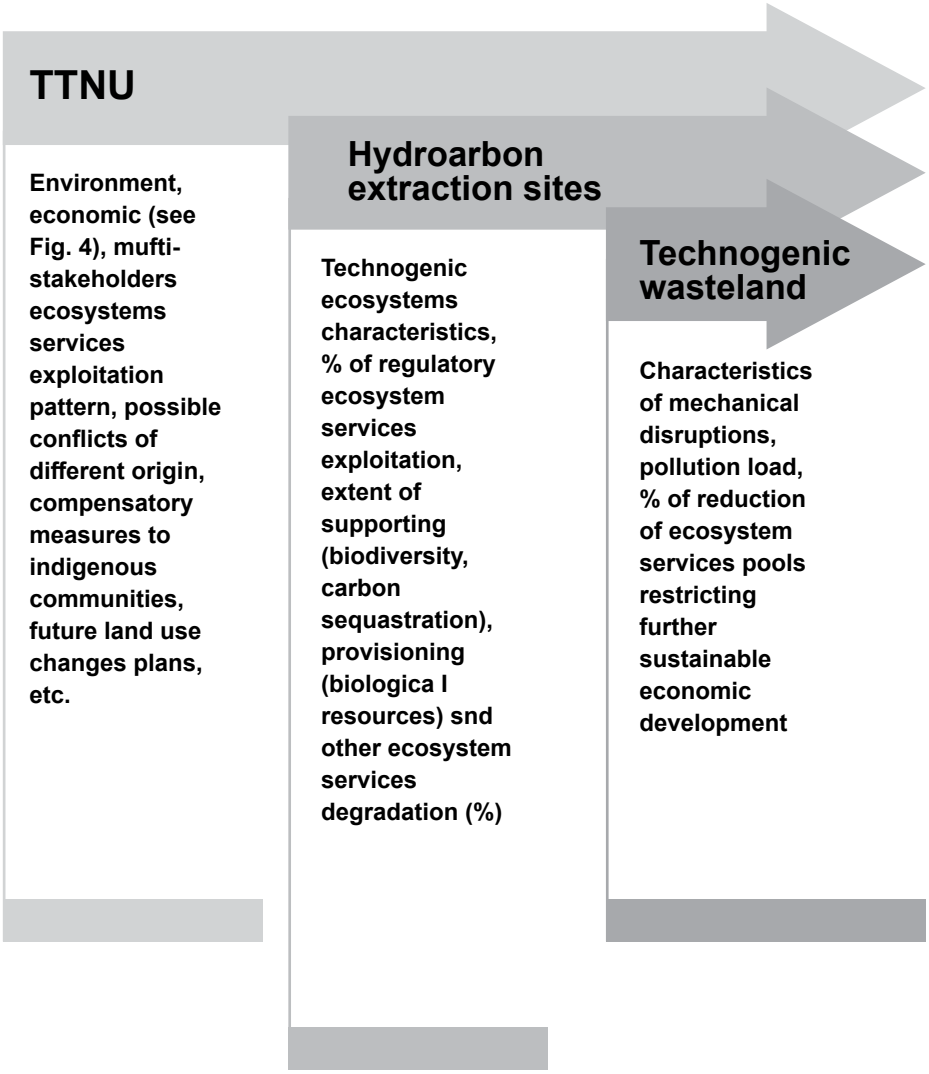


**Fig. 5.** **Data on possible land cover transitions and their results at TTNU.**

compensatory mechanisms. Information on Federal and regional economic development plans, possible investors and expected incomes are also included into this set.

#### 4.4.3. Ethnic assets

Ethnic-cultural factors explain what is necessary to consider managing a territory in a modern way without destroying traditional culture thus preserving indigenous population. Bi-cultural development is a form of neo-traditionalism explaining the necessity to exist in modern European and traditional indigenous culture for local communities. Demographic data, native speakers' number, reflecting ethnic identity, indigenous ethnic culture and desire to preserve it, types of traditional occupation (reindeer-breeding, hunting, fishing etc.), cultural heritage objects, including sacral places, etc. This information enables to make a primary forecast of possible social problems connected with economic development.

#### 4.4.4. Ecological assets

These data composition is highly changeable in time and space and demonstrates existing and potential ecological problems originated by economic development. Ecological factors reveal the existing sources of ecosystems degradation and natural heritage loss, undermining indigenous population welfare. Ecological data is needed for environment impact assessments of different economic development projects to meet sustainable development goals

#### 4.4.5. Ecological-economic assets

This information concerns measuring of ecosystem's multifunctionality relevant to available ecosystem services [De Groot et al., 2020, MacKtnna at al., 2019, Holting et al., 2019]. Risks of nature management conflicts caused by interference of different stakeholder's interests for exploitation of ecosystem services pools are shown in Table 1(Evseev et al., 2020). Regional data basis relevant to ecosystem services pools are still limited, but rough assessment may be done using average data for similar ecosystems from the World's list, or regional field

research [Costanza et al., 2014, Elsakov et al., 2003, Liss et al., 2000), etc.]. This may be enough at the initial stage for their rational management. It should be mentioned that customary laws of indigenous population for centuries regulated ecosystem services exploitation in order to avoid their depletion: bans on hunting and fishing during certain periods, grazing restrictions on unproductive pastures etc. Modern understanding of traditional knowledge may be helpful in this respect.

Table 1. COMPETING PATTERNS OF ECOSYSTEM SERVICES EXPLOITATION AT THE RUSSIAN COASTAL ZONE OF THE ARCTIC OCEAN

| Land use / environment management type | Industrial | Transport | Settlement / residential (nucleus) | TTNU |
|---|---|---|---|---|
| TTNU | Regulating, supporting | Regulating | Regulating, provisioning, supporting, cultural/ information | — |
| Industrial | — | Regulating | Regulating, supporting | Regulating, supporting |
| Transport | Regulating | — | Regulating | Regulating |
| Settlement | Regulating, supporting | Regulating | — | Regulating, provisioning, supporting, cultural / information |

### 4.4.6. Institutional assets

Adequate management of indigenous lands is regulated nowadays by the Federal and Regional legislation (which appears to be more advanced sometimes). International obligations should be presented as well. Indigenous population public activities are reflected by several NGO, participation in municipal social activities. The preserved indigenous customary laws data is a specific part of this set.

Spatial-temporal databases for these diverse factors are needed for different independent stakeholders involved in economic activities at TTNU. The multi-functional information platform to supply adequate data for practical use will be in demand by Federal and regional authorities (planning, control etc.), business structures of different levels, indigenous communities, and public organizations, nature conservation groups, etc. It is obvious, that this platform should be multi-level in temporal and spatial dimensions and renewable. The suggested information assets may include statistical, descriptive and spatial information as well as results of this information-analytical processing. Assets may be used in two ways: data transferring and new data creation, meaning integration of separate data from assets to create new data helpful for stakeholders. For example, revealing of nature management conflicts is at least based on the analysis of ecosystem services pools (environment/ecological-economic assets), different ecosystem services consumption by stakeholders (economic assets) and institutional limitations for their exploitation (institutional assets). The integrated data may be very helpful at the initial planning stage [Evseev et al., 2019, Swetnam et al., 2011]. Blockchain technology provides full traceability of data history and excludes data manipulation. Such transparency creates an opportunity for better management practice, regarding goals of sustainable development.

### 4.5. Prospects of blockchain use

The nature management transactions model for TTNU in case of the emergence of new overlapping land-use patterns is presented at fig.6. Regarding the principle users – indigenous communities, it should be mentioned that visualized data maybe recommended. Ethnologists note "visual perception" psychological type typical for indigenous peoples of the North. In case of information uncertainty and inadequacy, it enables them to control the situation keeping in mind the whole scenery. Integrated impact assessments may include both socio-economic and ecological data [Evseev et al., 2019; Ecological Atlas of Russia, 2017, etc.]. Visualized data sets most valuable for users are already available due to recent publications devoted to the study area [Ecological Atlas of Russia, 2017, The National Atlas of the Arctic, 2018, Evseev et al., 2018, 2019, etc.].

It is planned to test solutions based on blockchain technology for their applicability in for a model territory in order to elaborate platforms for building a distributed network of self-verified blocks of data, protected from unauthorized changes, and storing the history of entering data into the register. The main criteria for the platforms in question are:

1. Applicability of the assigned tasks solution. The block platform contains a single register of operations, each block of which contains information about the object, date, and time of changes, its author, as well as connection with the previous block (except for the primary block), verified using symmetric and asymmetric encryption algorithms.
2. The speed of operations. This implementation of the platform will allow the distribution of the operations' register (which is serviced by a network of p2p nodes) among an unlimited list of individuals in a way that makes the register of transactions and participants public. Since the publicity of the registry and the extensibility of the p2p network are unlimited, it is necessary to choose an implementation of the blockchain platform, which does not increase the complexity of generation in proportion to the number of participants.
3. Protection from transaction loss. Different platforms have different tolerance to transaction loss or the "erroneous" branch of blocks exclusion (for example, produced by the network errors, resulted in disconnection). The procedure for reapproving the transactions from the "erroneous" branch in case of conflicts may solve this problem. If chains are not represented in some copies of the operations' register, the platform should be able to carry out a "vote" on re-confirming the block or its tag is invalid.
4. Documenting solutions. The systems and approaches to be studied should contain fundamental documentation on how to implement the integrity of data, their consistency, and the voting mechanism. It is necessary to have a detailed description of the cryptographic functions used, their advantages, and disadvantages in the volume, allowing them to create a threat model.
5. Expandability. The decision to store data in a distributed public registry may be a starting point for achieving the objectives. It is necessary to assess the applicability of both existing

and unrealized approaches, for the sake of expanding the standard functionality (based on a platform implementation or integration with other systems without losing the advantages of blocking technology).

To use any existing blockchain-platform to ensure public interests, it is necessary to take into account factors of external pressure (such as restrictions on work in the framework of sectoral and/or country sanctions). Therefore, the important aspect of a system choice is connected with the possibility of self-implementation based on existing developments and, as a consequence, Open-Source solutions are more preferable. The software solution of the tasks based on existing platforms, their "forks" or completely independently developed solution should include the following components:

- register of objects;
- user storage and their rights based on the blockchain;
- identification and Authorization System;
- the network of p2p nodes that perform transaction approval and verification, create new blocks, and add them to the registry;
- application components for working with the system (monitoring, management, public API, user applications) (fig. 6).

## 5. Discussion

Blockchain technologies proved to be useful in many spheres of economic activities. The general recognized advantages of blockchain use are: decentralization, stability, enhanced security, and transparency. Blockchain method in land use/nature management, suggested for this information arrangement, nowadays is widely used in financial sphere and partly in Cadastral services [Suharevskaya, Kantyshev, 2018, Stefanović al., Torun, 2018, etc.] but its application in ecology, nature management is still rare, but some progress should be mentioned as well. "AgentschapvoorNatuur" end "Bos" nature conservation agencies in Belgium are planning to create a blockchain platform for nature conservation and forest protection issues [Building.., 2018]. Several other projects based at blockchain technology targeted at ecological problems solving should be mentioned as well. Among them is WePow-

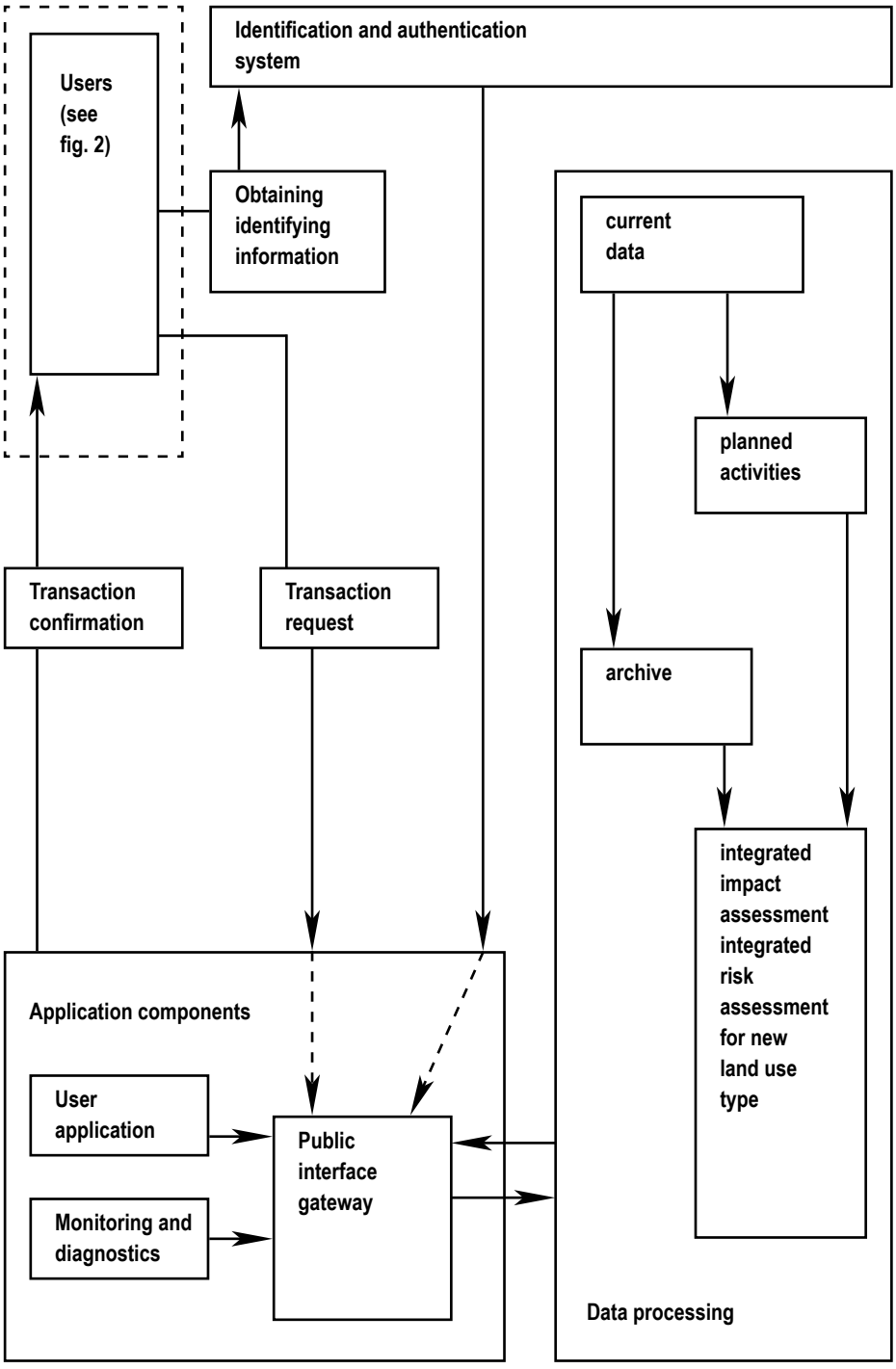


**Fig. 6. Blockchain transaction model for nature management at TTNU.**

er, which enable to create an infrastructure for unification use of "green" energy production and existing energy system [Walker, 2020]. Another "social" project is Plastic Positive, enabling people to invest into Social Plastic Collection Credits used for plastic pollution control [Plastic positive, 2020] Regen Network project is directed at tracking ecological change, monitoring and rehabilitation of destroyed lands, using blockchain for elaboration of rational land use patterns and includes special financial stimulating, monitoring and control [Regen network.., 2020]. One of the recent pilot projects in this field in Russia is DAO IPCI, connected with a platform construction to control carbon units use, contributions of different stakeholders to carbon dioxide exhausts, to attract investments into this process control, etc. [DAO IPCI, 2017].

These projects are the best confirmation of the principal tasks to solve ecological problems using blockchain technologies highlighted by the Fourth World Economic Forum. The mentioned tasks relevant to our studies are presented below:

— incentivizing circular economies – to provide proper use of natural resources and ecosystem services;
— increasing disaster preparedness and humanitarian relief;
— creating Earth-management geospatial platforms to monitor, manage and enable market mechanisms that protect the global environmental commons.

The presented here blockchain structure corresponds to these challenges. But its structure at the same time reflects different from the "entirely ecological" direction of blockchain use – nature management, demanding integrated data processing concerning economic, ecological, environmental, ethnic-cultural, etc. data. Proper nature management needs interdisciplinary solutions which are reflected in our assets structure. This structure composition is connected with available information for sets saturation and may be enlarged in future. For example, it is obvious that economic assets may be completed by the expected land cover transitions (see fig. 5). Still even the suggested variant may be helpful for stakeholders at TTNU to develop sustainable nature management patterns, providing full transparency and traceability within the supply chain. The key management tasks are monitoring and develop-

ment of market mechanisms to avoid the risk of ecosystem services' excessive exploitation threatening indigenous communities. This is of particular importance because they provide "feeding ecosystems" for indigenous population. Real-time transparent data on the ecological situation, natural hazards, cultural threats for indigenous identities, etc. may help municipal authorities to launch adequate measures to control the situation. Interdisciplinary solution based on specific "revolt" factors (when fast, small events overwhelm large, slow ones) in regional nature management systems connected with industrial and transport infrastructure development may provide sustainability to indigenous population living at the territories of the advanced economic development as well as demonstrate risks to TTNU connected with climate change and other natural hazards. These revolt factors typical for panarchy structures of socio-ecological spatial systems may be connected with non-linear processes in its environmental, ecological and socioeconomic subsystems xGunderson, Holling 2003, Evseev et al., 2019]. Management of panarchy systems demands spatial independent information processing promoted by blockchain technologies use.

## 6. Conclusion

Blockchain technology characterize the Fourth Industrial Revolution with the demand for a new, decentralized and global electronic infrastructure to meet the challenges of present and future time. Below we outlined the advantages of blockchain approach use at TTNU:

— development of a multi-functional platform necessary to ensure multi-stakeholders' interests, indigenous communes being among them;
— data bases for territorial and local (within TTNU) planning practice contributing to sustainable development and adaptation to modern climate change;
— temporal-spatial data assets independent storage and their constant updating available for indigenous communities (and other stakeholders);
— monitoring data necessary to forecast nature management conflicts (ecological, socio-economic, ethnic etc.) threatening indigenous identities.

Blockchain solution presented here is directed to promote sustainable pattern of the Arctic zone pioneer economic development taking into account indigenous population well-being and ensure optimal use of its nature capital via public-private collaboration. It demonstrates options for a sustainable resource management for other regions as well.

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## Об авторах

**Евсеев** Александр Васильевич, доктор географических наук, профессор, ведущий научный сотрудник географического факультета МГУ им. М.В. Ломоносова.
Тел. +7 495-939-39-92. E-mail: avevseev@yandex.ru

**Красовская** Татьяна Михайловна, доктор географических наук, профессор географического факультета МГУ им. М.В. Ломоносова.
Тел. +7 495-939-38-42. E-mail: krasovsktex@yandex.ru

**Тикунов** Владимир Сергеевич, доктор географических наук, профессор географического факультета МГУ им. М.В. Ломоносова.
Тел. +7 495- 939-13-39, E-mail: vstikunov@yandex.ru

**Тикунова** Ирина Николаевна, кандидат географических наук, научный сотрудник географического факультета МГУ им. М.В. Ломоносова.
Тел. +7 495- 939-36-31, E-mail: vstikunov@yandex.ru

## About the authors

**Evseev** Alexander Vasilievich, Doctor of Geographical Sciences, Professor, Leading Researcher of the Geographical Faculty, Lomonosov Moscow State University.
Phone +7 495-939-39-92. E-mail: avevseev@yandex.ru

**Krasovskaya** Tatiana Mikhailovna, Doctor of Geographical Sciences, Professor of the Geographical Faculty, Lomonosov Moscow State University.
Phone. +7 495-939-38-42. E-mail: krasovsktex@yandex.ru

**Tikunov** Vladimir Sergeevich, Doctor of Geographical Sciences, Professor of the Geographical Faculty, Lomonosov Moscow State University.
Phone +7 495- 939-13-39. E-mail: vstikunov@yandex.ru

**Tikunova** Irina Nikolaevna, Candidate of Geographical Sciences, Scientific Researcher Geographical Faculty, Lomonosov Moscow State University.
Phone +7 495- 939-36-31. E-mail: vstikunov@yandex.ru