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The Ecosystem Approach in Addressing Sustainable Development Goals through Citizen Science in Lithuania

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Abstract: This article presents an overview of the ecosystem of citizen science development in Lithuania and its potential to address United Nations sustainable development goals (SDGs). As citizen science is still in the early development stage in Lithuania, this case study is an example of ecosystem analysis in the period of early citizen science adoption. This article highlights the holistic analysis of the different components of this ecosystem, focusing on the three major dimensions at different levels—content, actors and processes. A conceptual model for the analysis of the citizen science ecosystem was developed based on the theoretical assumptions of Systems Theory and Service Science. The model was tested with empirical data. The empirical findings are based on 30 interviews with representatives of different stakeholder groups. Summarizing the analysis of the citizen science ecosystem in Lithuania and its potential for SDGs achievement, it can be stated that the first signs of a co-creative processes in the citizen science ecosystem have already emerged. Currently, in Lithuania, the main potential of citizen science concentrates on contributing to Goal #15: Life on Land, with some potential also for contributing to Goals #4, #10 and #11 and others. However, in order to use citizen science for addressing SDGs more comprehensively, there is a need for greater involvement of different stakeholders in citizen science, both in promoting citizen science activities and in ensuring data quality and that these activities are implemented in accordance with research ethics.

Keywords: citizen science; welfare society; ecosystem; SDGs; co-creation

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1. Introduction

Citizen science is often understood as a bridge between scientists and lay people, where non-professionals join scientific activities [1]. Such projects emphasize the partnerships between professional researchers and the public [2,3]. The growing number of international projects analysing and promoting citizen science and public engagement in science shows that more and more politicians and academics are interested in this way of engaging the general public in research [4]. This growing interest in the citizen science phenomenon is one of the drivers to use citizen science for solving social problems in society, in particular, making efforts to achieve the 17 United Nations sustainable development goals (SDGs). Citizen science comes as a method to bridge these two worlds, researchers and the public, to seek sustainability for societies.

In many countries, citizen science has already become a new field of research and it is quite common for the public to participate in citizen science activities. Communities of citizen scientists are supported by EU projects, universities or international networks such as the European Citizen Science Association (ECSA) [5]. However, there is a huge imbalance regarding the development of citizen science projects in different European countries. Western European countries such as UK, Germany, Spain, Switzerland and others have much better developed infrastructure for the implementation of citizen science projects and a wider awareness within the public of how lay people may participate in science compared to Central and Eastern European countries such as Lithuania, Latvia, Estonia, Hungary, the Czech Republic and others [5]. Lithuania serves in this article as an example of a country where citizen science is still taking its first steps. In Lithuania, citizen science as a term appeared in public discourse only recently, much later than in other Western countries [5]. This is one of the reasons why there are currently only a few initiatives in Lithuania that correspond to the concept of citizens' science. In this context, it is very important to understand the overall ecosystem of citizen science and its potential impact for society while the ecosystem is in its initial stage of development, including the analysis of content, actors and processes.

This article aims to discuss the potential of citizen science in addressing the SDGs through the lenses of an ecosystem. Conceptual analysis framework has been designed to provide insights on (1) the content of the citizen science projects and its potential to contribute to achievement of SDGs, (2) the major stakeholders in promoting public engagement in science and (3) the process of citizen science project implementation. The research strategy applied is more concerned with how the citizen science projects work in an ecosystem and not with the measurement of project outcomes. The results of the study allowed a holistic evaluation of existing strengths and weaknesses in relation to the changes and improvements that needed to be made in the ecosystem. The analysis shows that citizen science ecosystem in Lithuania indicates the first signs of a co-creative processes where different stakeholders are starting to show interest in citizen science. The signs also indicate the potential of citizen science to co-create solutions for achieving SDGs. Data show that in Lithuania, the main potential of citizen science concentrates for achieving Goal #15: Life on Land, and at some extent contributing to Goal #11: Sustainable Cities and Communities or Goal #4: Quality Education. However, in order to use citizen science for addressing SDGs more comprehensively, there is a need for greater involvement of different stakeholders. Such insights are useful for the designers of citizen science initiatives, policy planners and officials of governmental and educational institutions. The proposed analysis framework can be applied in evaluating the potential of citizen science in other countries as it is applicable in diverse settings and is not context dependent.

2. Conceptualization of Citizen Science Ecosystem in Addressing SDGs

Citizen science might be a powerful tool to collect information to address sustainable development goals (SDGs). As emphasized by Fritz et al. [6] (p. 922), citizen science "can complement and ultimately improve the SDG reporting process." The authors indicate when speaking about some official data sets that provide the data for tracking the achievement of SDGs in different countries that the issues of data timeliness, accuracy, openness and coverage are still not fully solved [6]. Thus, citizen science might be a good supplement to obtain data that is richer, with more detailed vocabularies, of denser coverage, wider in geographical scope and more timely to monitor the achievement of SDGs [6].

Moreover, citizen science belongs to the broader concept of Open Science, which describes a new approach to the scientific process based on collaboration and new ways of disseminating knowledge using digital technologies and novel collaborative tools [7]. The implementation of Open Science is an aim of the United Nations, but also one of the main strategic objectives of the European Union's research and innovation policy. Thus, citizen science, through its co-creative, participatory approach, is contributing to the openness and transparency of research.

Research found that in monitoring SDGs, "biodiversity and conservation are two areas with a strong citizen science presence and where contributions are already in evidence", especially for Tier I and II indicators [6] (p. 926).

However, there is still an open question of how citizen science might potentially contribute to the monitoring of SDGs in countries where citizen science is still a novel method of citizen engagement. Thus, a better understanding of the potential of citizen science in addressing the SDGs requires analysis of the dynamics of stakeholder engagement and the factors that ensure a smooth co-creation process. To achieve this goal, a conceptual model for the analysis of the Citizen Science Ecosystem was developed based on the theoretical assumptions of Systems Theory and Service Science. Both theories focus on the holistic analysis of phenomena and provide insight into how value is created in different systems. In general, systems thinking focuses on the totality of components rather than on its individual elements [8]. In this context, the relationship between different elements of the system and their interactions becomes more important than the individual components [9]. This is needed because research on individual systems often leads to incomplete results and recommendations with limited impact. These limitations are also present in the analysis of systems that influence the development of citizen science. Academics and practitioners tend to focus on the actors of collaborative systems and their motivation (e.g., [10–12]), technical and data management solutions (e.g., [13–16]) and the socio-economic context (e.g., [17–19]). However, the relationship between science and society is complex and influenced by many different socio-technological systems and needs broader analysis.

The importance of Service Science becomes apparent when trying to understand these multi-layered interactions between different systems. IBM and Cambridge University researchers defined Service Science back in 2008 as an alternative approach and research direction to analyse complex systems and how they combine resources to create shared value [20]. Service in this context is understood broadly as any process that adds value. The term ecosystem refers to the totality of socio-economic systems operating in an environment characterized by technology and information overload. Ecosystems are based on the principle of self-regulation between different systems through shared structures, social rules and co-creation [21]. From a service science perspective, value is created through three interconnected system processes [22]: resource integration, networking and service exchange. Value is created when multiple actors in a system collaborate for mutual benefit by providing access to each other's resources (e.g., people, technology and information). This means that ecosystem actors cannot create value (provide services) on their own, because no single actor (whether an organization or an individual) has all the resources it needs to achieve its objectives. The service ecosystem approach shifts the focus from the exchanges between two actors to the understanding that value creation is based on configurations of actors in economic and social networks [23]. According to [24], the ecosystem metaphor can be applied to any socio-technological domain and allows for the modelling of governance and policy visions.

The Policy Triangle Framework introduced by [25] provides guidance to categorize elements of the ecosystem into content, actors and processes. Thus, this framework facilitates the analysis of (1) the content of the initiatives, (2) the actors involved and (3) the process of co-creation that influences the development of citizen science initiatives. Figure 1 presents a model that allows a holistic analysis of the different components of the citizen science ecosystem to monitor the potential impact of citizen science for SDGs achievement.

In the *content* dimension, we will explore the content of citizen science activities and seek to understand what scientific problems citizen science is solving or can solve and its potential to contribute to SDGs monitoring. The content dimension is particularly important because often when looking at citizen engagement initiatives, the focus is on technological solutions and the form in which content is presented, but not on the content itself and its potential impact on societal issues. As the relevance of the issues and their adaptation to the needs of society are addressed more rarely, this dimension focuses on the content and its possible impact.

The active participation of professional and non-professional scientists (through new digital data collection tools and citizen engagement approaches) is a key factor in advancing citizen science [26,27]. For this reason, there is a need to better understand the roles and responsibilities of the participants of citizen science projects. The *participant* dimension analyses the roles, motivations and collaborative dynamics of the stakeholder groups involved in the ecosystem. While collaboration between different groups can lead to positive change, not all collaborative activities realize this potential. In many cases, it is difficult to find innovative solutions or to balance the interests of different stakeholder groups. This requires an understanding of the deeper goals and motivations of those involved. In the *process* dimension, we will analyse the drivers and constraints of co-creation processes at different ecosystem levels.

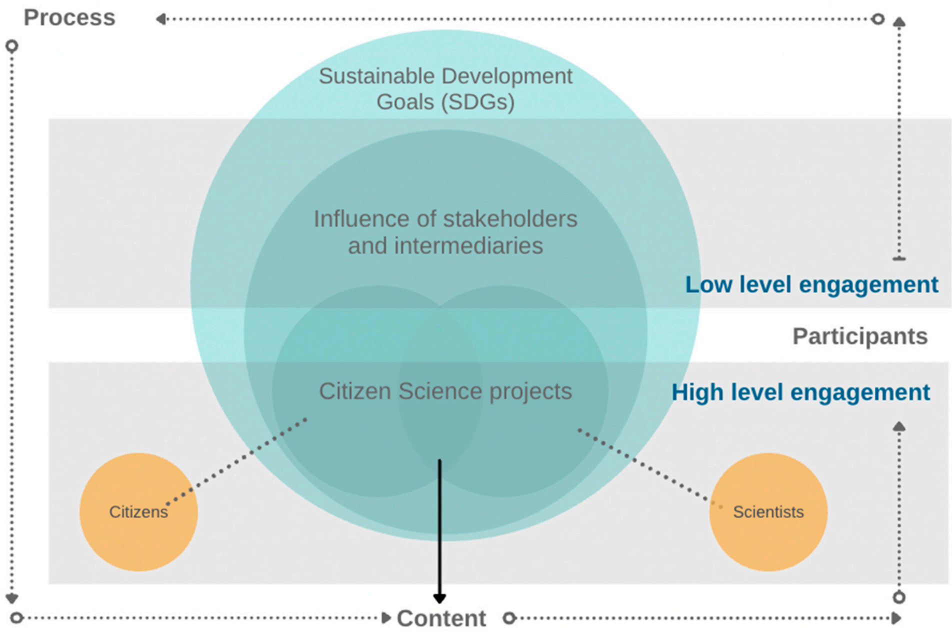

Figure 1. The conceptual analysis framework of a citizen science ecosystem for addressing SDGs (Adapted from ref. [28]. Copyright 2021 Kaunas University of Technology).

The ecosystem is divided into three levels. The first level analyses the interactions between scientists and citizens as key actors in citizen science initiatives. The second level analyses the impact of other stakeholder groups (e.g., universities, associations, municipalities, etc.) and intermediaries on micro-level collaboration. At the external level, the analysis assesses the political, economic and social contexts which influence science-society cooperation and are usually measured by different qualitative and quantitative indicators (such as GDP, GINI coefficient, Democracy index, etc.). Many of these indicators are used for monitoring SDGs. Thus, this latter level exhibits the SDG dimension in the analysis framework. The citizen science ecosystem approach was previously introduced by the authors of this article in their book [28], and in this article it has been adapted to analyse citizen science's potential impact on SDGs monitoring in Lithuania.

The actors in these levels of the ecosystem are classified according to their level of involvement: either high involvement or low involvement. According to [29], a high level of involvement means that actors are involved in the core processes of citizen science projects. For example, they define problem areas, initiate projects, collaborate and collect data. Actors with a low level of involvement are not directly involved in the activities, but influence citizen science processes (e.g., by setting strategic and funding guidelines for science), or use the data and project outputs generated by citizen science activities.

The proposed conceptual model provides a holistic approach and forms the basis for a clearer assessment of co-creation processes in the long term. The proposed analytical model provides a framework for further empirical research focused on a deeper understanding of co-creation through citizen science. The analysis of the different elements will be based the data collected during the interviews and compared with the findings of other studies.

3. Methodology

The proposed analysis model of a citizen science ecosystem was applied for an empirical study of the Lithuanian citizen science ecosystem, addressing the possible contribution to SDGs monitoring. The overall methodology included a two-step research strategy: conceptualization based on literature review and empirical exploration based on interviews' data.

3.1. Data Collection Methods

The qualitative research design was used to get a broader view of the elements of ecosystems. The qualitative research method was chosen because of its inherent depth and flexibility of engagement with the different actors. The data obtained allows for a variety of unforeseen characteristics of the phenomenon under study to be revealed. According to the assumptions of subjective theory, different professionals have different knowledge of and experience with the subject matter. Semi-structured interviews were chosen as an empirical research method because they are meaningful when one needs to know the attitudes, evaluations, experiences and opinions of the research participants.

The interview questionnaire consists of four interrelated diagnostic blocks: (1) the interviewee's characteristics and information about his/her activities; (2) the understanding of citizen science and the experience of participation in citizen science projects; (3) the added value of citizen science: the need for citizen science, possible contribution to achieving SDGs and benefits for researchers, citizens and other stakeholder groups; and (4) the threats and risks related to citizen science for different stakeholders and the research process itself.

To achieve the objectives of the study, a mixed sampling procedure was used, incorporating criterion, convenience and snowball techniques. In the first stage, the sample was selected by means of a criterion sampling method, i.e., a list of criteria to be met by the participants in the study. The two main selection criteria were: (1) the subject belongs to one of the stakeholder groups; (2) the subject is a highly qualified professional with expertise in the specific field of activity. The criteria selection was based on convenience sampling, where the first participant was selected according to the set criteria as the most accessible and relevant, based on the personal contacts of the researchers. Once the first respondent had been selected, a snowball sampling approach was applied, whereby one research participant recommended another potentially suitable respondent. The proposed participants were interviewed if they met the selection criteria.

A total of 30 in-depth interviews were conducted with a wide range of stakeholders: (1) researchers (coded as R1, R2, R4, R9–12, R14–R15, R17 and R29–R30); (2) citizen scientists and citizen science project promoters, including teachers and specialists of non-formal education (coded as R18–R22, R24–R28 and R3–R6); (3) representatives of University administration (coded as R7 and R13); (4) policy makers (coded as R16 and R23) and (5) NGO representatives (coded as R8). The anonymity of the interviewees has been ensured and therefore only their identification codes are included in the data analysis. The questions were tailored to the needs and expertise of each stakeholder. The interviews lasted between one and two hours. The interviews were organized between February and May 2021.

3.2. Data Analysis Methods

The aim of the content analysis is to link the research insights with the dimensions of the analysis framework. The analysis is based on the interpretation of information expressed in textual form. To achieve this, NVivo 10 software (release 1.6.1, QSR International, Doncaster, Australia) was used to assign codes to text fragments, to group and regroup them and to expand and narrow the list of codes as the work progressed. The data analysis software allowed for an increased level of accuracy, to obtain more details and to standardize the working conditions of the researchers interpreting the recordings. In order to objectively and systematically analyse the features of the text, the data analysis was carried out following the strategy proposed by [30]:

(1) Idea generation and description. At this stage, each interview was analysed several times. This is necessary in order to identify the main elements and circumstances shaping the citizen science ecosystem in Lithuania, as identified by the interviewees;

(2) Preparing data for further analysis. At this stage, a coding system was developed based on a conceptual model for the analysis of the SDGs achievement through the approach of the citizen science ecosystem in Lithuania, which is characterized by three dimensions of analysis (actors, process and content) and three levels (the cooperation between scientists and citizens; the impact of stakeholder groups; and the political, economic and socio-cultural environment). The qualitative data analysis matrix is presented in Figure 2.

MATRIX OF ECOSYSTEM ANALYSIS	ECOSYSTEM LEVEL 1	ECOSYSTEM LEVEL 2	ECOSYSTEM LEVEL 3
Participants	*Quotes from interview participants*	*Quotes from interview participants*	*Quotes from interview participants*
Process	*Quotes from interview participants*	*Quotes from interview participants*	*Quotes from interview participants*
Content	*Quotes from interview participants*	*Quotes from interview participants*	*Quotes from interview participants*

Figure 2. The qualitative data analysis matrix.

(3) Categorization and identification of themes. By comparing the data on the basis of similarities and differences in the aspects discussed by the interviewees, recurring themes and categories are identified and extracted;

(4) Identifying category relationships and interfaces. This stage identifies the relationships between constructs and the processes involved in the situation. Several supporting strategies were used: abstraction, deduction, contextualization and numbering. Similarities and differences in the relationship between the variables are revealed by identifying extreme, atypical cases and combining related cases that are close in content to the relationship. The relationship is explained by comparing it with the scientific insights provided by other authors.

The qualitative content analysis provides a deeper understanding of how the Lithuanian citizen science ecosystem is perceived by its participants and how it helps or hinders the achievement of SDGs in Lithuania. The application of this strategy allows for the gain of a comprehensive understanding of an individual's, a group's or a culture's impact on the different processes of citizen science engagement. An analysis of these data was partly presented in [28].

4. Results

4.1. Content of the Citizen Science Ecosystem

The interviews conducted with representatives of the different stakeholder groups allowed for a better understanding of the citizen science projects that are already taking place in the Lithuanian ecosystem. The interviews revealed only a few instances of scientists' participation in citizen science projects and most of these are linked to projects abroad (e.g., R1: *"I was involved. I had an internship related to citizen science. My first experience was in Sweden"*). Scientists have heard the term "citizen science," but often have little practice in initiating or developing such projects (e.g., R2: *"I have only heard and read about this, as I said, I was not participating in any citizen science project"*; R17: *"I am familiar with the term "citizen science". But it was really not easy to understand that term at first. And not easy, first of all, primarily due to the fact that there were not many examples of citizen science in Lithuania or that I was not involved in any citizen science project"*).

The situation is different for citizen scientists. The very fact that these informants could be categorized as citizen scientists shows that these members of society have some kind of practice of participation in citizen science projects. In Lithuania, these practices are often associated with teachers and students becoming involved in international citizen science projects (e.g., R18: *"I do this together with children. I have been carrying out these observations since 1999").* On the other hand, there are emerging initiatives in universities to develop citizen science projects or analyse this phenomenon, mainly through the implementation of international projects that are funded by EU research and innovation programme Horizon 2020, the Erasmus+ programme or similar, or national projects that are funded by Research Council of Lithuania.

On the basis of the interview data, it is possible to identify a number of citizen science projects in Lithuania: such as iNaturalist; Globe Project; Baltic Sea Project; Rally of the Species, Tree Guards, On Brone Pajiedaite's path and others. Many of these projects also involve schools, pupils and their parents and serve as a good example of how school communities get involved in citizen science. All of these projects clearly indicate the potential to contribute data for sustainable development Goal #15: Life on Land. This finding corresponds to the previous international research results indicating that citizen science has the biggest potential to contribute to collecting data on biodiversity and conservation [6].

Interviewees also indicated scientific projects that were not specifically designed to start citizen science projects, but in their nature, they might be called citizen science. This might be illustrated with several examples. One example was presented by researchers representing educational sciences and management. While implementing a project related to open schooling, researchers involved schoolchildren to contribute data on young people's perception and attitudes toward the future, science and scientific developments, as well as their motives for engaging in science-related activities. Such an example shows potential to contribute data for addressing Goal #4: Quality Education. Another example presents a project that involved local communities monitoring their social problems by using citizen science methodology. This second example shows the potential of citizen science to contribute data for monitoring the well-being of communities, which might be related to Goal #11: Sustainable Cities and Communities. One more example of the EU-funded project that explores youth social inclusion through youth engagement into citizen science, might be an illustration of addressing Goal #10: Reduced inequalities. These examples do not cover all existing initiatives in Lithuania on how citizen science projects are contributing to SDGs and to which goals they contribute, as more explicit research should be done to scan this situation. On the other hand, these examples indicate that there are emerging citizen science initiatives that have a potential to contribute data for monitoring SDGs.

The limited experience suggests that citizen science is not yet a recognized and/or widely accepted method of public engagement in science. However, the root initiatives, particularly the involvement of the younger generation, signal that citizen science and its visibility will grow in Lithuania in the future.

4.2. Actors of Citizen Science Ecosystem

First, we will discuss the high involvement actors in the Lithuanian citizen science ecosystem—researchers and citizens.

The interviewees' identified six aspects of researchers' roles and responsibilities in citizen science projects: (1) to initiate the projects (e.g., R13: *"The call has to come from scientists. Probably, many people do not know that there is such a possibility at all"*; R14: "*Scientists, starting with children, should already be talking about what it is, showing platforms < . . . > The first step in our society is that scientists have to start and educate*"); (2) to provide in-depth explanations about the data collection and analysis processes (e.g., R7: "It *would be our duty as researchers to provide instruments where citizens can easily collect data, contribute with their opinions, capacities, volumes*"); (3) to inform about the results of the projects (e.g., R11: "*If there is collaboration and publicity for the knowledge that is co-created, it is the responsibility of the researcher to communicate the results to the citizens who have been involved in the research*"); (4) to provide consultations to stakeholders (e.g., R20: "*We are always getting feedback from NASA scientists. In our school, we already have more than a hundred stars, i.e., evaluations, NASA scientists' evaluations, which are given every three months*"; R21: "*The scientists helped us to identify the tribes, because it is quite difficult for the pupils*"); (5) to collect and manage data following guidelines on academic ethics (e.g., R11: "*Just like about the protection of individuals,* *I think that is really our responsibility*"; R2: "*The different legal things they will have to deal with < . . . > And obviously it is up to the scientists to do the enforcement of these things*"); and (6) to perform a broader function of educating the general public (e.g., R11: "*At the same time, I think it would be very useful for educating the public in general. Especially in this context where we hear a lot of hatred, a lot of intolerance. I think it would contribute a lot to the maturity of society*").

Discussions on the roles of citizens in citizen science projects mostly were directed at activities for raising awareness and how to disseminate information to citizens that such projects exist (e.g., R12: *"The need to be involved in scientific processes is certainly not something I hear from citizens themselves. Which is maybe quite sad, because in my experience in Lithuania, citizens are not very interested in science, they are sceptical about research, its reliability and results. And I have not yet heard from citizens themselves to articulate their interest in participating in research*"; R23: "*Here the citizen must also be reassured and must ask questions*"). The role of citizens in the later stages of projects were discussed less frequently. This is largely due to the limited cooperation between science and society in Lithuania. According to interview participants, citizens themselves do not feel the need to be involved in scientific processes, which could be attributed to cultural and historical backgrounds (e.g., R4: *"In Eastern Europe, it is very difficult to involve people in such global projects. Individually, yes, but it is difficult to organise some kind of an organised project to make it successful < . . . > Purely because of the cultural and social aspects*"; R": *"We are still burdened by that legacy. Everything in the collective is very suspicious*"), low curiosity levels (e.g., R5: *"The public is less curious, less interested in some scientific news and prefers to receive all information already processed*") and citizens' struggle to meet basic needs (e.g., food, shelter and job security) (e.g., R15: *"When we have such a huge percentage of citizens who are dealing with basic problems, we cannot expect them to seek fulfilment through volunteering").*

Nevertheless, the interview participants were able to identify the roles of citizens in citizen science projects. They were as follows: (1) citizens as initiators (e.g., R2: "*Nowadays, you can find all the information you need online. I think that citizens themselves can initiate that research < . . . > so it would not be difficult for them to find ways or scientific methods to carry out that research*"); (2) citizens as problem-solvers (e.g., R11: "*We could ask them to articulate the problems, because I think they feel it. We often feel and know the problems that should be solved by research on our side. However, our perception is a bit different*"); (3) citizens as additional resources in the research process (for data collection and processing) (e.g., R7: "*I see citizens as a very big resource < . . . > Because if we say that the skills of scientists are a certain resource to solve problems, then there are fewer scientists than there are people in general, all other people*") and (4) citizens as consumers of solutions (e.g., R5: "*Whether it is medical science or politics, in any case, all decisions that are taken are in the name of citizens in one form or another < . . . > I think it is no longer possible to eliminate citizens, it is obsolete. Because citizens are involved in everything and they are usually the consumers of those decisions, whatever they may be*").

The analysis of the interview data allowed us to identify five groups of low involvement actors in the Lithuanian Citizen Science ecosystem: (1) advisors of international citizen science projects (R17–20; e.g., R20: " *The first time we heard about citizen science and we were really introduced to it in a big way, it was our Globe project advisors and her lectures*"); (2) informal education institutions providing support for executing international citizen science projects (R3, R19, R20, R22, e.g., R22: *"The Lithuanian Centre for Non-Formal Education offers a lot of activities. You just need the motivation*"); (3) teachers conducting citizen science projects in schools (R18, R19, R20, R24, R28 e.g., R20: '*And as teachers, we teach. We teach the children and we explain what they should raise*"); (4) higher education institutions that provide access to highly qualified professionals, interdisciplinary networks, infrastructure and funding sources (R7, R9, R10, R11, R12, R14, R23, R29 e.g., R12: "*As this movement is very young, it needs structural solutions and support. First of all, if the university or the institutions that fund the projects would allow the citizens involved in the projects to be included in the research budgets, it would really make the process much easier, much faster*") and (5) governmental organizations that shape education and research policy by setting guidelines on the criteria against which both researchers and higher education institutions will be evaluated (R2, R7, R9, R13, R23 e.g., R13: "*For this to work, there must be political support. Is it documented, is it documented that there is political support for it*"; R2: "*First of all the ministry itself should understand the value. And more would initiate those or support projects with that*"). Despite the added value of citizen science applications for different groups of actors, the potential of these activities is diminishing due to the unavoidable logistical tensions caused by time, personnel, funding and other resource constraints in the Lithuanian education system.

4.3. Processes in Citizen Science Ecosystem

The assumption was made that co-creation is the central process in the citizen science ecosystem for addressing SDGs. Hence, the following sections will explore the factors influencing the success of co-creation.

First, the factors influencing cooperation between scientists and citizens will be discussed (level 1 of the ecosystem). The analysis of the interview material revealed the main principles shaping the collaboration between scientists and citizens were respectful relationships (e.g., R17: "*It's just that the risk here depends very much on the researcher. If he or she is disrespectful to citizens and they feel underestimated, unappreciated. Emotionally there can be some unpleasant things. If there is some kind of miscommunication with the researcher*"); the inclusion of different stakeholder groups (e.g., R11: "*It is important that we reach out to all segments of society, all social groups*"); a systematic and unified approach to the problem through cooperation (e.g., R1": "*Mutual cooperation, where a consensus is reached and the problem or phenomenon is understood, both in terms of the problem or the phenomenon itself, and in terms of the whole issue*); the practical application of scientific research (e.g., R8: "*This is also, it seems to me, where science should also take into account that changing social environment and adapt to it*"); a clear structure for collaboration (e.g., R12: "*There needs to be a lot of initial discussions before you can start to co-create something*"); creativity (e.g., R16: "*It is a creative process that something is born out of talking, out of thinking, out of sharing)* and timely feedback (e.g., R16: "*Co-creation is like a two-way traffic < . . . > the feedback should be continuous*"). In order to implement these collaborative principles, researchers need to be upskilled and their attitudes towards citizen engagement need to change. From the citizen's perspective, participation should be based on the principle of voluntariness (e.g., R12: "*The citizen should not feel pressured or obliged in any way, but it should certainly be voluntary*"). This is necessary because citizens may not be aware of all of the risks involved in the research process (R14: "*People may not be aware of all those risks, what it means, for example, that they are involved in, perhaps, some experiments on their own, as participants, or that they are collecting the data already at that time*").

Second, we will discuss the influence of communication and institutional tools in co-creation processes.

The communication and dissemination of information are crucial to the success of projects in any field. This is particularly true in citizen science, where projects rely on public participation and citizens do not always have sufficient knowledge of scientific processes. According to [31], communication is an ongoing process that maintains openness between all actors at every stage, from the identification of research questions to the publication of results. In addition, to be effective, communication activities need to be well planned and resourced. Communication tools or groups of communication tools identified by the interviewees as enabling a closer relationship between science and society are: (1) consistent and sustained communication (e.g., R5: "*Even if you broadcast them once, it does not mean that the public will remember. Because they need to be repeated consistently, patiently, sensitively, taking into account their social differences and needs, opportunities and situations*"); (2) communicating the added value of citizen science for citizens (R3, R15, R16, e.g., R3: "*The best citizen science initiatives are the ones where you yourself still get some benefit from the game itself, but just from knowing that you are making a small contribution to science.*"); (3) communicating the added value of citizen science for researchers (e.g., R2: "*There is a lack of resources to explain the added value of citizen science. Why then involve citizens? Scientists need to understand that by engaging citizens they can get closer to them, better understand their needs and better identify problems*");

(4) changing the vocabulary used (R7, R8, R11, e.g., R7: "*When you go to people, you have to speak in normal, ordinary human language 'It's not always that simple. The whole way of communication, engagement should be different*"); (5) the promotion of citizen science tools (e.g., R": "*We are not doing research ourselves. We are promoting iNaturalist. 'We're promoting to use the thing < . . . > 'We're trying to get people involved in this*"); (6) the consultation of citizens during the project's duration (e.g., R4: "*In order to get good quality data, there needs to be interaction between scientists and the citizens who collect the data. That is, there should be consultation on the part of the scientists*"); (7) a better understanding of the scientific audience (e.g., R2: "*Now we are thinking of doing a study on the attitudes of the Lithuanian population towards science*"); (8) the organisation of pilot projects (e.g., R7: "*In a university, it would be possible to see the result in pilot, local projects*"); (9) showcasing international experiences (R1, R6, R14, R23 e.g., R14: "*I think that through participation in international European projects, or just reading the guidelines, taking part in the training, writing the applications, which applications have been funded, it is very visible*") and (10) developing guidelines for successful project implementation (e.g., R4: "*How to encourage them, how to help them*").

The institutional measures shaping the success of co-creation in citizen science projects can be divided in to four broad categories: (1) initiating change at institutions towards more openness (e.g., R11: "*Collaboration can be achieved through communication, which starts from the university side*"); (2) the organisation of training activities for researchers in order to increase their capacity to engage the public (e.g., R17: "*There is also an institutional responsibility that if we are doing citizen science or promoting it, then we need to train people doing it are*"); (3) initiating change in organisational culture (e.g., R7: "*It's very much a question of organisational culture*") and (4) establishing new staff positions focused at public engagement (e.g., R23: "*A researcher may want to involve citizens or work with the public in other ways. But he does not know where to start. There has to be experts that he can lean on to give him all the knowledge and know-how he needs to get started and to support him*"). These measures would initiate change. However, it is important to remember that universities and other research institutions are also heavily regulated, which makes it difficult to introduce new processes, so they need political support from higher education policy makers.

Finally, there is a need to evaluate the strategic direction provided by public institutions and the national context in general. Although the inclusion of different groups of citizens in the processes is often mentioned in the documents shaping science strategy, according to the interviewees, the opportunities for their inclusion in the Lithuanian science ecosystem are still limited (e.g., R9: "*I think it is almost impossible at the moment, because there is a very clear set of criteria that filter who can enter and who cannot enter the science processes*"). In Lithuania, there is a huge gap between science and society, as the science system is closed and it is hard to admit innovative approaches such as citizen science (e.g., R5: "*The biggest problem in Lithuanian society is the fragmentation and the huge disconnect between academia and society*"). The problems are not only on the scientific side. According to other studies and this one, citizens themselves in Lithuania have little interest in science and are sceptical about research, its reliability and its results (e.g., R12: "*I have not yet heard citizens themselves express an interest in taking part in research*"). The public sees science as a bureaucratic system without the freedom and opportunity to carry out independent and reliable research (e.g., R7: "*It all comes from our history and our occupations, which have lasted a long time. Very much the worldview of the people, that kind of worldview was in a box in a very tiny enclosure, I think. And it is very difficult to get out of it*"). Interviewees stressed the need for a change in the attitude of science policymakers towards a more mature relationship between science and society. There is a lack of clear leadership in communicating the importance of science to the public (e.g., R23: "*Our politicians need to talk about the importance of science and public education and to create mechanisms through which we will do this*"). When identifying the factors that would ensure a smoother co-creation process, the majority of interviewees pointed to the need to adapt the criteria for evaluating and funding scientific activities (R4: "*Nothing will change until the evaluation of outputs changes*"). Work involving citizens is not valued, so researchers rarely find the motivation or time to carry out such projects (R1, R23, R24 e.g., P2": "*Public engagement is not valued at the same level as pure science. So, then scientists might think, why am I doing this if I'm not going to get the same promotion or the same bonus as someone who did not engage and did research using traditional methods*").

5. Discussion of the Results

The analysis showed that the content of citizen science projects in Lithuania is characterized by high fragmentation and a small number of citizen science projects, especially the national ones. There is usually more involvement in international citizen science projects. Research also shows that the existing projects have a potential to contribute to Goal #15: Life on Land, and to some extent also might contribute to Goal #11: Sustainable Cities and Communities, Goal #10: Reducing Inequalities, Goal #4: Quality Education and/or other goals. These findings are in line with the previous research results, indicating that citizen science has the biggest potential for biodiversity and conservation research [6]. However, this research cannot cover the current overall situation of the initiatives that are contributing data to the achievement and monitoring of SDGs, and for such an analysis, a more comprehensive study is needed. On the other hand, these illustrations and examples show that we can already identify some potential in Lithuania for using citizen science in addressing SDGs.

Actors of the Lithuanian citizens science ecosystem differ according to the level of their involvement in citizens' science activities (high vs. low).

Researchers were identified as high-level involvement actors at the core of the ecosystem. The interviewees identified many roles and responsibilities of researchers: educating the public, explaining research processes, initiating citizen research projects, advising other groups of actors, collecting and managing data in accordance with academic ethics and informing about the progress and results of projects. The central role of researchers has been discussed in the works of [32,33]. While there is diversity in citizen research projects, researchers often play a key role in these activities, not only sharing their scientific knowledge with the general public, but also enabling citizens and communities to apply their own research methods to address relevant social problems. Nevertheless, researchers are not widely acquainted with methods of citizen involvement in scientific processes. This is often due to limited time resources and lack of necessary skills, as well as the low level of cooperation between science and society in Lithuania.

Another high involvement actor group, citizens, was assigned four categories of participation during the interviews: initiators, problem makers, resource generators (data collection and processing) and solution users. Although citizens' participation in citizen science projects in Lithuanian is still very low, there are signs of a growing interest in science and participation in international citizen science projects. The roles of citizens in the Lithuanian citizen science ecosystem, as identified by the interviewees, are echoed in international research on citizen engagement. For example, [34] proposed a three-dimensional framework describing different ways of participating in science. The framework includes normative (public involvement in decision-making), epistemic (public involvement in knowledge generation processes) and public outreach (the accessibility of project results outside the academic system) dimensions. Each of these dimensions describes a continuum between researchers and the public, which is also evident in the interviewees' discussions.

Low level involvement actors include the advisors of international citizen science projects, teachers, Lithuanian non-formal education institutions and their employees and higher education and government institutions. The research shows that both higher education [34,35] and governmental [36,37] institutions play an integral role in promoting the involvement of citizens in research processes. However, their activity in the Lithuanian citizen science ecosystem is very limited. In order to motivate both citizens and researchers to develop their citizen science projects more actively, changes are needed in the strategic documents and guidelines for funding research, which would allow for the proper evaluation of researchers' work in co-creating research projects with the public.

Finally, when analysing the co-creation processes in the citizen science ecosystem in Lithuania, two perspectives are distinguished: co-creation as a process (the dynamics of actors' cooperation and factors influencing it) and co-creation as a result (collectively created knowledge, changes and added value for different ecosystem actors). The research revealed elements of successful co-creation in citizen science projects, i.e., respect-based relationships, the involvement of different groups of actors, a systematic and coordinated approach to the scientific problem, voluntary citizen participation, feedback, creativity and the proper motivation of actors. However, institutional changes in research and innovation are needed, since most of the stakeholders operate under little—if any—guidance by the national government. Interviewees pointed to the lack of political leadership in making science more open and limited resources to support citizen engagement activities. Similar problems can be found in other countries and contexts, too, since citizen science is still an emerging practice [38,39].

Most importantly, the communication between different institutions and stakeholders in the ecosystem is mostly one-way and inconsistent. The views of the interviewees are in line with the recommendations of [31], who argue that citizen science projects need to go beyond the traditional top-down approach and engage in a two-way dialogue with project actors. A single responsible ecosystem actor or group of actors is not enough to intensify communication of the opportunities for citizen engagement. For a more participatory approach to public engagement, a coherent collaboration between individual researchers, higher education institutions and public organizations is needed, both to raise the profile of citizen science activities and to ensure the smooth implementation of projects.

6. Conclusions

The ecosystem approach is a relevant tool for understanding and exploring the interactions between different actors, institutions and contexts in society. Co-creation is a key process in the citizen science ecosystem, which means that stakeholders work together towards a common goal. Research and innovation systems are complex and made up of many complementary elements. Their effectiveness is determined by how these elements interact with each other and respond to the needs of the wider economic and social system. When summarising the analysis of the citizen science ecosystem in Lithuania, it can be stated that the first signs of a co-creative ecosystem have already emerged. However, most of the activities are rooted in the personal motivation of citizens, scientists and teachers. There are no institutional or national level measures (i.e., incentives, guidelines or sharing of knowledge) motivating stakeholders to participate. In order to realise the potential of citizen science to address social problems, there is a need for greater involvement of different stakeholders, both in promoting citizen science activities and in ensuring that they are implemented in accordance with research ethics.

Citizen science has the potential to contribute to better achievement of SDGs by helping to build the capacity of society to understand scientific data, creating opportunities to obtain more data from different stakeholders, bridging and consolidating different stakeholders through co-creative processes and creating an enabling environment to integrate different perspectives, opinions and methodologies. However, this potential is not yet fully used in Lithuania. Although there are emerging initiatives of citizen science projects that might potentially contribute data to monitor Goal #15: Life on Land, and at some extent contribute to Goal #11: Sustainable Cities and Communities, Goal #10: Reducing Inequalities or Goal #4: Quality Education, more comprehensive research is needed to scan and analyse citizen science contributions in addressing SDGs in Lithuania.

The research presented has several limitations which could be improved in the future. First, the evaluation of an ecosystem is based on the availability of data. Since citizen science is an evolving concept with limited application in the Lithuanian context, some important drivers or barriers of the implementation could have been missed due to the limited number of experts with knowledge on citizen science in the Lithuanian context. Second, the interview method predetermines other types of limitations, mostly related to the subjectivity of participants. The proposed analysis model has several limitations too—the definition of complex and emergent socio-technical systems is unavoidably partial, context-specific and temporary. Additional work is needed to formulate measures and indicators of successful co-creation initiatives in citizen science. It is hence important that more and more research documents the methods of co-creation in citizen science projects focused towards reaching SDGs. Further research exploring citizen ecosystems in other countries would be useful in the elaboration of the model.

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