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# Pathway to Green Transformation in Lithuania: Biogas Production from Manure and Waste

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**Abstract:** Green transformation at the beginning of the 21st century occupies the top positions in modern society's sustainability transition research and policy debates due to its multiple propositions of various innovations, addressing the still unsolved issues of rapidly on-going societal and technological changes. Rooting from the general climate change concerns, recently, sustainability transformation has become a special focus in the EU, which is facing new and very concrete demands—to elucidate the evidence-based pathways towards the green transformation with European Green Deal and European Climate Law targets ahead. The main aim of this research is to disclose the pathway towards the green transformation in Lithuania in one of the fast-growing research fields of circular bioeconomy—biogas production from manure and waste. To reach this aim, a hybrid methodology approach was used. Analysis and synthesis of scientific literature, document analysis and structuring, stakeholder mapping, interviews, and statistical analysis methods had been applied. Research results gave evidence for one of the five proposed possible ways for green transformation in Lithuania—the regime transformation. Interviewed stakeholders repeatedly defined this as the most probable pathway for green transformation in Lithuania in the field of biogas production from manure and waste, considering the best suitability of the current development state in the field: adjustments of existing industries, skills, regulations, and institutions.

**Keywords:** sustainability transition; green transformation; development pathway; circular bioeconomy; biogas production; stakeholders; European Green Deal; Lithuania



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## 1. Introduction

The second decade of the 21st century arrived with a new panacea, broadly known as "green transformation" (hereinafter GT), which currently occupies all the top positions in modern society's research, development, policy, as well as professional debate arenas. Despite the fact that the roots of the GT lead back to the 19th century, when the very first attempts concerning climate change observations came into scientific elaborations in review papers, books, scientific conferences, and other forms [1,2], the GT has found its momentum in recent decades [3,4]. The second part of the 20th century gave birth to the new roots of environmental concerns in sustainability discourse with the famous United Nations (hereinafter UN) of Brundtland's report (1987) ahead, issuing a clear focus for the "right" common future of nations—a sustainable pathway [5].

In the 21st century, the continuity of the issue, assured mainly by the global Paris Agreement (2015) [6], turned into exceptional urgency in the EU and resulted in ambitious EU policy, settled in the European Green Deal (2019) [7]—to reduce the GHG emissions by at least 55 percent by 2030 (compared to 1990 levels), and climate neutrality by 2050, striving to become a first climate-neutral continent. The ambition became driven by numerous initiatives in the EU, and some of them appeared in such imposable and powerful forms as the Climate Pact (2020) [8,9], despite the issued confrontation from a few powerful nations in the World [10–13]. The most important current updates in the policy are placed in the

Climate Target Plan (2020) [14], which fostered the European Climate Law (2021) [15], adopted by the European Parliament and the EU Council in June 2021. The European Climate Law [15] legitimated the EU focus on the five key objectives: (1) setting the direction for the long term through all policies, in a socially fair and cost-efficient manner, to meeting the 2050 climate neutrality; (2) setting a more ambitious EU target 2030 for putting Europe on a responsible path to becoming climate-neutral by 2050; (3) creating a system for monitoring progress and taking further action on demand; (4) providing predictability for investors and other economic actors; and (5) ensuring the irreversible transition to climate neutrality. Thus, the third decade of the 21st century started with the sustainable development in the EU switched into a strictly institutionalized and well-legitimated pathway for green transformation, which should meet very clearly defined targets.

The sustainable development pathway with the initial GT ideas inside, also referred to as sustainability transition and transformation towards sustainability, has been addressed in many scientific debates throughout the last decades under a range of different perspectives, recently focusing on measuring and experiments [16,17], frameworks of agroecological transition [18,19] and farming [20], agriculture and food systems [21], and financial [22], economic and urban [23] sustainability transitions. Many scenarios regarding the different pathways had been elaborated for climate action within the UN sustainable development goals in Agenda 2030, by stressing the importance of simultaneously tackling a different crisis on the transformation towards sustainability [24]. Currently, the questions of methodological diversity concerning sustainability transition research are at the heart of the scientific debate in the field [25].

Among the key elaborations of the sustainability transition, significant scientific developments had been achieved concerning modeling a multi-level perspective on the pathways towards sustainability [21,26–31]. The early considerations of a multi-level perspective on technological transitions as evolutionary reconfiguration processes [26] had been further aligned with a shift from sectoral systems of innovation to socio-technical systems, considering the dynamics and change from sociology and institutional theories [27]. After referring to the multiple criticisms concerning the multi-level perspective on the issue [28], the findings had been fulfilled with modeling politics and power influence on regime transformation in low-carbon economies [29]. The lately proposed agenda for sustainability transition research [30] and developed multi-level framework of sustainability transition processes [31] suggests a research framework, broadly applicable to explore sustainability transition pathways in different fields and contexts, including the GT.

The multi-level perspective [31] considers the evolutionary path of radical innovation as the starting point and puts its transformative path on scale and time dimensions. The transitions come over time through the interplay between processes on different scales or levels of society—niches, regimes, and landscapes. There are three scales of analysis. The first level emphasizes the emergence of a small scale and local level—niche innovations. Here, the key role is played by pioneering entrepreneurs, activists, and other outsiders who need a "protected space" from the market and hold enough potential to learn and develop. The second level corresponds to a regime, a particular state of the socio-economic system, in which the innovation needs to survive, considering the steering, promotion, as well as limitations for behavior. The third level represents the context and landscape of radical innovations, a broad scale on which the developments occur. The multi-level perspective emphasizes that transformative path starts normally occur on a niche level, and together with the landscape (different contextual pressure, rules, etc.) they push the regime forward towards transformation. Normally, the socio-technical transition is a long and complicated process and goes through the four key phases [31]:

(1) Experimentation—a very local level, laboratory experiments, real-life experiments or demonstrations, huge uncertainly level, and high rate of failure.
(2) Stabilization—already established innovations in one or more market niches and first reliable flow of resources.

(3) Diffusion/disruption—the diffusion into the mainstream markets, when support for innovation causes the business to struggle, and the economic and political forces of a regime. The innovation might fail in the face of these struggles.
(4) Institutionalization/anchoring—the replacement of an old system with a new one at some or all parts, and the institutionalization of replacements in the form of new policy models, programs, etc.

The transitions are specific according to the contexts and vary between places, but the overall general dynamics remain the same. Moreover, the transition normally takes time. Such an approach served to form a theoretical framework for measuring the five possible pathways towards the GT (see Table 1) [32].

**Table 1.** Possible pathways towards the green transformation.

| Title of the Pathway | Description of Change Characteristics |
|---|---|
| 1. Technological substitution | New economic activities will replace the existing industries, which will be closed. |
| 2. Regime transformation | Existing industries, skills, regulations, and institutions with be changed to adjust the new requirements. |
| 3. Regime reconfiguration | There will be radical reorganization of the existing industries, and new positions will be occupied by new actors. |
| 4. De-alignment and re-alignment | Existing industries will disappear and the dominant actors will be grown from small niches. The change will be led by surviving companies and technologies, combined with new industries. |
| 5. Industrial exhaustion | Deep conflicts will block the green transformation. Protests will react macro-level pressured. |

The application of this framework [32] is further explained in line with this research, aiming to define the Lithuania-specific pathway(s) for GT in the fast-growing research field of circular bioeconomy—innovation in biogas production from manure and wastes. In recent years, innovation in the field of biogas production became increasingly addressed in scientific research [33–36]. Some studies [33] argue that the increasing attention to biogas production from alternative energy sources occurs due to the general lack of energy sources. Moreover, biogas production not only generates the energy resources, but at the same time produces valuable and beneficial fertilizers for agricultural field. Other investigations [34] give broader reasoning for biogas production from various biomass sources (wood, aqua, agriculture), including waste (human, animal and industrial), addressing the fossil fuel depletion and adverse environmental factors, such as climate change due to greenhouse gas emissions [34]. It is often stated in research that energy production from various organic sources and biomass at the same time corresponds to solving multiple issues: first, and the most important with regard to the GT is the neutral $CO_2$ effect from energy production; second, large and continuous availability; third, comparatively low cost, compared to other sources [34,35]; finally, energy self-sufficiency [36]. Recent research also focusses on the different means of biogas production. For instance, experimentation with biogas production from poultry litter gave evidence that the re-use of poultry litter causes the increase in biogas production, whereas the fermentation gives the opposite results [35]. Thus, the given overview proves the growing importance of the selected research area of circular bioeconomy. In this article, the focus is given to the very first outlined issue—the Lithuania-specific pathway towards green transformation, based on the biogas production from manure and waste practices in the agricultural sector. The Lithuania-specific pathway towards the GT began much earlier than the European Green Deal (2019) [7] and related acts had been adopted by the European Commission. The historical circumstances and political development of Lithuania played a very significant role concerning the arrival of sustainability issues onto the country's agenda. Since the very beginning of the regained independence from the Soviet Union in the 1990s, Lithuania started its initial steps, which were necessary to enter the ongoing broad debate of Western Europe concerning climate change and the overall context of the future of the competitiveness of the Lithuanian economy in transition. In September 1991, Lithuania joined the United Nations (hereinafter referred to as UN), and this acted as a powerful acceleration mechanism for the development of a legal base concerning a range of environmental issues, which are currently referred to as the GT. Different initiatives at the very beginning addressed

the general and rather fragmented concerns in the field of climate change, which were further unified under the principles of sustainable development in different national-level strategies and programs of the Republic of Lithuania, concerning sustainable development (afterward—smart specialization; recently—the course of the European Green Deal) [7].

A few years after Lithuania regained independence, the industry from Soviet times had been destroyed. This resulted in the significant advancement of a country's environmental state in the context of the EU, since key environmental measures sharply decreased. For instance, net $CO_2$ emissions in 10 years, i.e., 1985 (last decade of the Soviet Union) and 1995 (first decade of independence) decreased more than 2 times, from 33.4 to 15.0 million metric tons, respectively [37]. Hence, the most recent figures show that, in the Year 2020, Lithuania reached 11.9 million metric tons of $CO_2$ emissions, thus comprising 0.04 percent of the share of the World's $CO_2$ emissions [38].

Environmental concerns in Lithuanian young democracy development quickly gained momentum. All institutional processes had been tightly interconnected to the United Nations' guiding initiatives around the world, basically the Rio de Janeiro Declaration (1992), Agenda 21, UN Framework Convention on Climate Change (1994), and leading documents.

Parallel to this, many other initiatives contributed to the pathway of Lithuania towards the GT. The United Nations Framework Convention on Climate Change in Rio de Janeiro had been signed by Lithuanian representatives in June 1992 and entered into force on 22 June 1995 after ratification in Lithuania Parliament. Thus, the Lithuanian National Strategy for United Nations Framework Convention on Climate Change Implementation was institutionalized in 1996 and the First National Communication on Climate Change of the Republic of Lithuania was issued in 1998.

A significant decade-length contribution concerning environmental issues belongs to Mr. Valdas Adamkus, one of the respective Presidents of the Republic of Lithuania (1998–2009). Being a reputable and well internationally recognized environmentalist, he made a significant shift in environmental thought in Lithuania. The preconditions for sustainable development in Lithuania had been rooted as a long-term strategy of the overall country's development. The team of advanced Lithuanian scholars, leading practitioners, and foreign experts were united to give birth to the Long-term Sustainable Development Strategy of the Republic of Lithuania, which was approved in 2003 and might be titled the first legal action to start the institutionalized pathway of Lithuania towards the GT.

It is worth stating that the pressure to accelerate the processes towards sustainability was exceptionally high at the international level. Based on the listed UN acts and the World Summit in Johannesburg (2002), the UN countries intended to develop national strategies on sustainable development. It is worth considering that Lithuania's sustainable development principles and goals were precisely elaborated on the grounds of national interests and concerns. The experienced and well-recognized working group was formed at the state level and united all urgent stakeholders: government, business, science representatives, and newly born young NGOs. The working group, based on the experience from Western Europe and relevant countries' needs, issued a long-term priority: "to reach the current average of the European Union member states by 2020, according to the economic and social indices as well as the indicators of population health and the efficiency of consumption of natural resources, also ensuring a clean and healthy environment" [39].

After the revision of the EU Sustainable Development Strategy in 2006, the EU member states (Lithuania joined the EU on the 1st of May 2004) were obliged to revise their strategies for sustainable development according to the most recent relevant circumstances. The analysis of the Lithuanian Sustainable Development Strategy [39] implementation reports gave evidence on the need to update it. In 2012, the updated Lithuanian National Strategy for Sustainable Development was issued with the same goal, but more emphasis on the critical roles of innovation, science, social responsibility of the private sector, and broader public involvement in the further sustainable development of a country. National interests, revitalized with the most relevant EU Sustainable Development Strategy (2006) foresight, were settled in priorities and objectives of the new version of Lithuania Sustain-

able Development Strategy, as well as relevant leading acts in the field. Further updates to the Lithuanian National Strategy for Sustainable Development were made due to the new course that appeared at both national and the international levels: National Progress Strategy "Lithuania 2030" (2012) [40], UN "Transforming Our World: the 2030 Agenda for Sustainable Development" (2015) [41], and National Progress Plan 2021–2030 (2020) [42].

The most relevant Lithuanian national strategic document—the National Progress Plan (2020) [42]—considers the three key guiding principles for Lithuania in the coming decade: (1) sustainable development; (2) innovation (creativity); and (3) equal opportunities for all. Thus, by listing the key driving forces, the pathway towards the GT is institutionalized at the top-level in Lithuania.

Herein, the biogas production from manure and waste stands for the above-discussed innovation in this research from a broad field of circular bioeconomy. The selected innovation is part of the currently acting Lithuanian Smart Specialization Strategy in the priority "Agro-innovation and food technologies", with a particular focus on "Processing of Biological Raw Materials (biorefinery)". The valuable investigations concerning the issue had been conducted as part of the GRETA project research [43]. The greatest transformative capacity of the selected area—circular bioeconomy (biogas production from agro wastes) from the point of GT is based on the already implemented spatial practices in Lithuania in the field of energy (biogas) production from manure and other agricultural wastes. The multiplied practices are preassumed to accelerate GT in the agricultural sector in Lithuania.

The main aim of this article is to disclose the pathways towards the GT in Lithuania in one of the fields of circular bioeconomy—biogas production from manure and waste. To reach the aim, a further described hybrid methodology approach was used. Analysis and synthesis of scientific literature, document analysis and structuring, stakeholder mapping, interviews, and statistical analysis methods had been applied.

## 2. Materials and Methods

Conducted research consisted of four steps that allowed us to reveal Lithuanian pathway(s) toward Green Transformation (GT) in the biogas production sector from manure and waste. At each step, different methods were applied to validate the results of the research:

1. Analysis of legal documents and strategies on GT;
2. Mapping of stakeholders in the biogas sector (from manure and waste) in Lithuania;
3. Semi-structured interviews with selected stakeholders;
4. Data analysis (descriptive statistics).

### *2.1. Looking for the Strategy on GT: Documents Analysis*

Legal documents analysis was used to formulate and initiate the basis for further scientific research. At this stage of the research, there have been analyzed legal documents, strategies towards GT on a national level, as well commitments, planning, and policies on the EU level. Analysis of legal documents, strategies, and commitments revealed Lithuania's current situation in implementing GT in the biogas production sector, as well the future vision towards it.

### *2.2. Mapping of Stakeholders in the Biogas Sector in Lithuania*

The Quadruple Helix approach [44] was used to identify four key groups of stakeholders in the biogas sector from manure and agro wastes in Lithuania:

- Private organizations (processors of manure and waste, producers of biogas);
- Governmental organizations (ministries dealing with the implementation of Smart Specialization (RIS3) strategy and regulating biogas production from manure and waste);
- Research organizations (universities and research institutes working on sustainable energy, agriculture, rural development, etc.);
- Non-governmental organizations (NGOs) (organizations representing society, rural communities, farmers, and customers).

The Stakeholder Salience Model [45] has been used to map relevant stakeholders in the field of interest. This model has been adapted to a macro-level analysis. Following the methodology [45], stakeholders were selected using 3 criteria, power, urgency, and legitimacy, considering their influence on the GT in Lithuania in biogas sector (more specifically, biogas production from manure and waste). Based on the Stakeholder Salience Model, each stakeholder corresponds to one of 7 types of stakeholders: dormant, discretionary, demanding, dangerous, dependent, definitive (see Table 2).

**Table 2.** Stakeholder's types.

| Stakeholder Types | Power | Legitimacy | Urgency |
|---|---|---|---|
| Dormant | 1 | 0 | 0 |
| Discretionary | 0 | 1 | 0 |
| Demanding | 0 | 0 | 1 |
| Dangerous | 1 or 2 | 0 | 1 or 2 |
| Dependent | 0 | 1 or 2 | 1 or 2 |
| Dominant | 1 or 2 | 1 or 2 | 0 |
| Definitive | 2 | 2 | 2 |

According to the described typology, stakeholders were classified into strong (definitive), moderate (expectant), and weak (latent). These categories are important in understanding the shift direction, i.e., how the important stakeholders should be moved from weak or latent positions, towards more strong, i.e., definitive, when accelerating the changes on the pathways towards the GT. This is referred to as stakeholder salience measurement [32]. A developed map of relevant stakeholders has been used for the selection of the most relevant respondents.

### 2.3. Interviews with Selected Stakeholders

The aim of the interviews was to assess the pathway to GT in the biogas sector from manure and waste in Lithuania. This was achieved by mapping the Quadruple Helix [44] involvement by the most active stakeholders by employing four steps of analysis. Firstly, during the interviews, the power, urgency and legitimacy of each stakeholder were validated. Secondly, the stakeholders' relevance for GT has been measured by measuring their actions towards sustainability—whether they are promoting a sustainable system or diminishing it. Thirdly, stakeholders' level of influence on niche, regime and landscape level has been measured. Finally, the pathways (technological substitution, regime transformation, regime reconfiguration, de-alignment and re-alignment, institutional exhaustion) toward GT have been evaluated. This research design has been developed by the University of Vaasa in cooperation with the Regional Council of Ostrobothnia and used in different research [46–48].

Aiming to evaluate the involvement of four stakeholder groups after the Quadruple Helix approach [44], which are in the chain of biogas production from manure and wastes, distribution, consumption and regulation in Lithuania, a semi-structured questionnaire was used. The questionnaire consisted of 20 questions targeting the vision, strategy of GT, the ways to move GT forwards, connection between national, regional and EU levels on GT, the role of the region, pathways toward GT, evaluation of national stakeholders and their actions, potential opportunities and threats, etc.

Interviews were conducted in March–April 2021. At least 1 respondent had been interviewed from each component of the Quadruple Helix Model. In total, 7 interviews had been conducted with appropriate representatives: 2 with the private sector, 1 with the government sector, 3 with research institutions, and 1 with NGOs.

### 2.4. Data Analysis

Data received during interviews were analyzed to answer the following research questions:

- How can one enhance the GT in Lithuania in the field of biogas production from manure and waste?
- How do different stakeholders view and experience GT in Lithuania—as promoting a sustainable system or diminishing an unsustainable one?
- What is the connection of niche (product), regime (national), and landscape (EU) level in promoting GT in biogas production in Lithuania?
- Which pathway of GT is most likely to proceed in Lithuania?

Several common qualitative analysis steps had been taken to analyze the data, collected during the interviews. First, the transcripts of every interview were read and annotated. Then, the data were contextualized. Afterwards, the segmentation of collected data had been done. Then, the segments were analyzed and research result interpretations were written, answering the researched questions. Detailed data analysis according to the outlined questions and steps is explained in the following section.

## 3. Results

The results revealing pathway(s) to GT in the biogas sector from manure and agro wastes in Lithuania are presented in this section. The results are described in two sections based on the logic of research that was explained in Section 2.

### *3.1. Mapping of Stakeholders for GT in the Biogas Sector from Manure and Agro Wastes in Lithuania*

In total, 14 stakeholders were identified for assessment of GT in the biogas sector in Lithuania. Stakeholders were selected from four key groups using the Quadruple Helix approach: (1) private organizations (21%), (2) governmental organizations (29%), (3) research organizations (29%), and (4) non-governmental organizations (21%) (see Figure 1).

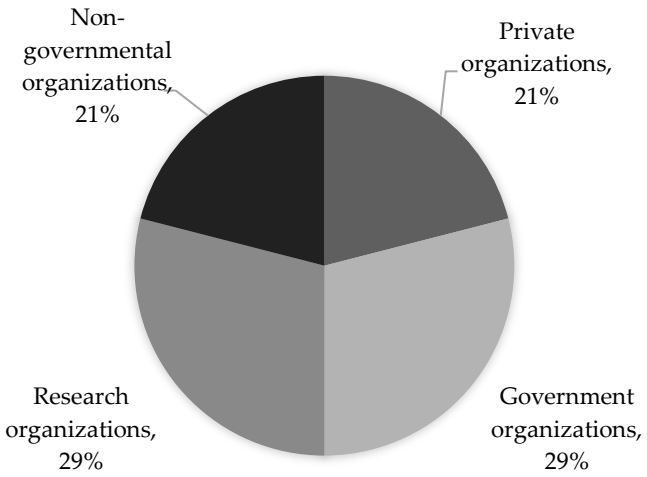


**Figure 1.** Selected stakeholders from four key groups for the biogas sector in Lithuania.

The selection of stakeholders was based on their relevance to GT in various initiatives and strategies in Lithuania and the EU in the past, today, and in the future. Urgency, legitimacy and power of stakeholders were evaluated, considering their relevance, i.e., the ability to drive the GT in Lithuania. This is defined by two key components: first, working in unsustainable diminishing systems and promoting sustainable systems, and second, the influence of stakeholders on niche, regime and landscape level. Stakeholders are expected to take dynamic positions in the future to perform relevant activities and changes towards GT at the regime level.

3.1.1. Power, Urgency, and Legitimacy of Stakeholders

Selected stakeholders for the biogas sector in Lithuania are with different combinations of urgency, legitimacy, and power, based on the Stakeholder Salience Model [45]. The level of urgency was measured according to the following criteria:

- Whether business organizations are changing material flow, creating new networks, value chains and new products to employ innovative biogas production solutions GT and to what extent (great/moderate/none);
- Whether research organizations are working on research, education and dissemination on topics relevant to GT and to what extent (great/moderate/none);
- Whether public organizations are implementing regulations and policies promoting GT and to what extent (great/moderate/none);
- Whether NGOs are enhancing GT and to what extent (great/moderate/none).

Level of legitimacy was measured according to the following criteria:

- Whether business organizations are carrying activities that are desirable and proper from a GT point of view and to what extent (great/moderate/none);
- Whether research organizations are carrying research and education activities that match with GT and to what extent (great/moderate/none);
- Whether public organizations are preparing and implementing GT development programs and regulations and to what extent (great/moderate/none);
- Whether NGOs are focused towards the environment and to what extent (great/moderate/none).

Level of power was measured according to the following criteria:

- Whether business organizations are able to act indecently, make market decisions on their own and to what extent (great/moderate/none);
- Whether research organizations have power to implement GT-friendly education and research activities and to what extent (great/moderate/none);
- Whether public organizations are setting rules and norms for biogas production from manure and waste in line with GT and to what extent (great/moderate/none);
- Whether NGOs have power to actively engage decisionmakers, to lobby and get wide support and to what extent (great/moderate/none).

Private organizations have the highest level of urgency, governmental organizations have the highest level of legitimacy and power, and research organizations and non-governmental organizations hold lower urgency, legitimacy, and power.

Detailed results on stakeholders' power, urgency, and legitimacy are provided in Table 3.

**Table 3.** Stakeholder's power, urgency, and legitimacy for biogas production from manure and agro wastes in Lithuania.

| Stakeholder | Stakeholder's Strength in GT | | | | | | | | | Relevance in GT |
|---|---|---|---|---|---|---|---|---|---|---|
| | Urgency | | | Legitimacy | | | Power | | | |
| | 5 Years Ago | Now | in 5 Years | 5 Years Ago | Now | in 5 Years | 5 Years Ago | Now | in 5 Years | |
| Private organizations | | | | | | | | | | |
| Stakeholder 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | Dominant; prospective experienced leader in biogas; active in new biogas solutions. |
| Stakeholder 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | Dependent; regional experienced experts in biogas; active in collaborative solutions for GT. |
| Stakeholder 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | Dependent; experienced producer of biogas. |

**Table 3.** *Cont.*

| Stakeholder | Stakeholder's Strength in GT | | | | | | | | | Relevance in GT |
|---|---|---|---|---|---|---|---|---|---|---|
| | Urgency | | | Legitimacy | | | Power | | | |
| | 5 Years Ago | Now | in 5 Years | 5 Years Ago | Now | in 5 Years | 5 Years Ago | Now | in 5 Years | |
| Research organizations | | | | | | | | | | |
| Stakeholder 4 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | Dependent; active in bioeconomy management solutions for GT. |
| Stakeholder 5 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | Dependent; active in technological bioeconomy development solutions for GT. |
| Stakeholder 6 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | Dependent; active in bioeconomy higher education for GT. |
| Stakeholder 7 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | Definite; experienced implementer of collaborative GT in biogas. |
| Governmental organizations | | | | | | | | | | |
| Stakeholder 8 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | Dominant; focus on economic growth and innovation policy including GT. |
| Stakeholder 9 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | Definite; focus on environmental issues including GT. |
| Stakeholder 10 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | Definite; focus on implementation of actions for GT. |
| Stakeholder 11 | 1 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | Demanding; demand for more active role in green energy decisions. |
| Non-governmental organizations | | | | | | | | | | |
| Stakeholder 12 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | Demanding; demand for increased bottom-up role in GT. |
| Stakeholder 13 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | Definite; driving force for GT at local level. |
| Stakeholder 14 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | Dependent; supporter of GT at sectoral level. |

Score meaning: 0—no stakeholder actions; 1—moderate stakeholder actions; 2—active stakeholder.

*Urgency of stakeholders*

All stakeholders from private organizations 5 years ago, now, and in 5 years are considered maximally urgent since their environmental will to add to GT is crucial for businesses. They are used to perform changes in material flows, create new networks and compose value chains with indirectly new products—biogas from manure and agro wastes—thus demonstrating their urgency and potential in GT to make actual change.

Research organizations in terms of urgency are given the highest score '2', since they were always the urgent leaders regarding the role in research, education, and dissemination on topics relevant to GT, even though this was much earlier than the analyzed period of stress.

The urgency of governmental stakeholders 5 years ago was evaluated '1', except for Stakeholder 9, since other ministries were not seen in the GT process as urgently. Currently, the urgency of governmental stakeholders increased (score '2'), and it is also expected to keep this increase in the following 5 years regarding national and EU regulations and policies promoting the transformation of landscape and regime levels.

Non-governmental stakeholders' urgency in Lithuania concerning the activities for enhancing GT, is expected to increase in the coming 5 years, since the current environment will be considered as quite limited, holding a sufficient potential for increase. This is mainly addressed for Stakeholder 12 and Stakeholder 13. From the urgency point of view, Stakeholder 14 increased their role and activeness, compared to the previous 5 years, so currently and in 5 years their urgency is scored "2".

*Legitimacy of stakeholders*

Stakeholders from private organizations, in terms of legitimacy, received moderate evaluations, since the desire to perform GT in their everyday practice is high, but the actual

conditions for doing this are restricted with legislation, requirements and continuously changing schemes. Private companies sometimes have very restricted abilities to act for GT, since legislation in particular cases forces them to do unprofitable practices when acting appropriately with legislation.

Stakeholders representing research organizations, currently, and in the following 5 years, were awarded the highest score "2" since the education and research programs of the universities currently perfectly match the focus of GT. However, five years ago, the situation was slightly different since the GT ideas had not been so explicitly outlined. Education and research programs even 5 years ago already included various aspects of the GT, but it was not the systemic approach it has recently become and is expected to be in the next 5 years.

Governmental organizations as stakeholders have received the highest scores of "2" in preparation, decision-making, and implementation of GT development programs and regulations, except Stakeholder 11. However, it is highly expected to see a much greater role played by Stakeholder 11 in GT in line with other relevant government stakeholders, and it requires further developments towards GT in the future.

Concerning the non-governmental organizations as stakeholders, greater environmental and GT focus (score "2") is expected from Stakeholder 12 and Stakeholder 14, since currently there is a resting potential to utilize this for more prosperous territorial and sectoral development. Hence, sufficient environmental and GT focus was observed regarding Stakeholder 13 in Lithuania. Therefore, it is expected from them to keep this direction regarding the GT in the next 5 years. The legitimacy of NGOs at the local level concerning the GT issues might be increased with the help of government representatives, who arrange the variety of rules for supportive measures for local development. Currently, it is observed that various programs (e.g., the CAP and the Rural Development Program—the RDP) set the ambition of GT in their vision and among the aims; however, the implementation measures, which are implemented by local action groups and rural communities using these instruments, often are limited with short-term accountability, so long-term sustainability by itself is ignored by such programs.

*Power of stakeholders*

Stakeholders from private organizations received different scores regarding the power in the timeline. Five years ago, Stakeholder 1 and Stakeholder 2 received the score "1" since their power to act independently and make market decisions on their own had been moderate due to the overall business activity environment in the field of biogas production. Hence, Stakeholder 3 had a more powerful position because the biogas plant was only a part of the main activity of the company. Thus, its ability to act independently in the overall biogas production market was greater than the rest. Currently, Stakeholder 1 holds its best ability to act independently (score "2") and make market decisions on its own, since the company has already established its own zero-waste production practice. Specifically, wastes, produced on the pig farm, go to the heating and fodder drying on the farm, meaning that the company is not as affected by the electricity purchasing price of the national grid as much as it was 5 years ago. In 5 years, it is expected that companies will have sufficient power (awarded "2") to act independently and make market decisions on their own.

The power of stakeholders from research organizations to implement GT-driven education and research activities is moderate since both the education and research programs are approved by the Ministry of Education and Science of the Republic of Lithuania and other relevant education and research-supporting institutions. Only Stakeholder 7 currently has slightly greater power since it is more focused on practical education issues. It is expected by stakeholders from research organizations that the power should increase in the following 5 years.

The power of stakeholders from governmental organizations undoubtedly is scored "2", since setting the rules and norms for environmental issues is an essential function to be performed by government institutions for GT in Lithuania. The least empowerment of rules and norms concerning environmental issues in the selected area of intervention

had been observed by Stakeholder 9. The situation should be necessarily moved forward regarding the GT in the following 5 years.

The power of non-governmental organizations concerning the GT in the biogas sector from manure and agro wastes in Lithuania has received a favorable evaluation. The ability to actively engage decision-makers and active lobbying, as well as a wide support base, was evaluated with the highest scores in the two examined cases for Stakeholder 13 and Stakeholder 14. These two stakeholders were powerful enough 5 years ago, they are currently powerful enough, and they are expected to be powerful enough in 5 years. Hence, the situation of Stakeholder 12 is different. They were considered moderately powerful 5 years ago, and they are currently considered moderately powerful. It was observed that this stakeholder as an umbrella organization does not directly take part in GT strategic processes, including the CAP, national RDP, etc. They normally give their bottom-up position and suggest measures in arranging the programming documents; however, these suggestions typically are not taken into account in the final versions of the CAP and other implementation documents. So, still, there are a few blind spots, and collaboration with decision-makers remains complicated.

The overall summarized picture of ratio between urgency, legitimacy and power of stakeholders in Lithuania in the field discussed (see Figure 2) is developed using the above-described Mitchell's Stakeholder Salience Model approach [45].

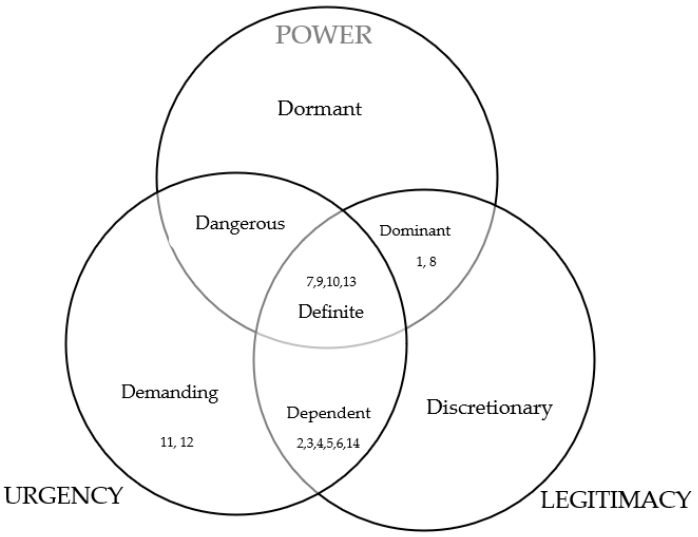


**Figure 2.** The salience of stakeholders towards GT in Lithuania. Source: elaborated by authors from the research results, following Mitchells et al.'s (1997) methodology [45].

It was revealed that the most relevant and powerful stakeholders (governmental organizations of Lithuania) are driving the green strategy, and they are nonetheless important for future success because they have power, legitimacy, and political influence (urgency). A major part of definite stakeholders are government institutions (Stakeholders 8, 9, 10) and to some extent research (Stakeholder 7) and non-governmental (Stakeholder 13) organizations. Research organizations are seen as educators and facilitators of various initiatives related to GT aiming to propose various instruments and methodological tools leading to cooperation, co-creation, and networking of all four helixes. A few stakeholders from private (Stakeholder 1) and governmental (Stakeholder 8) sectors play a dominant role and have immense potential to become definite stakeholders. A significant portion of analyzed stakeholders are dependent stakeholders. Stakeholders from the private sector (Stakeholders 2 and 3), research institutions (Stakeholders 4, 5 and 6), and from the NGO sector (Stakeholder 14) have been evaluated as dependent stakeholders. Dependent stakeholders rely on only one robust actor, and they can be easily replaced, as the knowledge they apply can be accessed without difficulty. Dependent actors compete to obtain and

maintain their positions, and they may demand attention, legitimacy, and urgency. Most of the stakeholders from the NGO sector (Stakeholders 11 and 12) have been identified as demanding stakeholders. Demanding stakeholders have urgency, but they experience the lack of power and legitimacy. These stakeholders are eager to be involved but lack the resources and significance to be heard.

#### 3.1.2. Stakeholders' Actions towards Sustainability

GT for identified four key groups of stakeholders is and/or was earlier and/or will be important, but the reasons for that importance are diverse. The different reasons can be explained by the different sectors they are representing: For private organizations, GT for selected stakeholders was/is/will be important, as it is a part of their business model, their revenue, and their choice for greener technologies. For the research organizations, GT was and is in many cases a reaction to the EU discourse and trends, and it is a part of their strategic goals, which must be in compliance with the EU and national strategies. It is believed that as GT trends and significance are getting stronger and more important, the GT will become more important in the education and science sector. The main reasons why GT is important for the governmental organizations are very similar to those explaining why it is important to the education and science sector—as there is a greater demand on GT form the EU and national strategies and plans, the GT becomes more important to the public sector. Non-governmental organizations are the fourth group of stakeholders to whom GT is an important aspect of their activities, as it may be a tool to preserve ecosystems and other aspects they are advocating for, as well as it is important to comply with requirements coming from the EU and national level regarding GT and stricter requirements for their activities.

Detailed results on stakeholders' relevance to GT are provided in Table 4.

**Table 4.** Stakeholders' relevance to GT for biogas production from manure and agro wastes in Lithuania.

| Stakeholders | Promoting Sustainable System | | | Diminishing Unsustainable System | | |
|---|---|---|---|---|---|---|
| | 5 Years Ago | Now | in 5 Years | 5 Years Ago | Now | in 5 Years |
| Private organizations | | | | | | |
| Stakeholder 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| Stakeholder 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Stakeholder 3 | 1 | 1 | 1 | 1 | 1 | 1 |
| Research organizations | | | | | | |
| Stakeholder 4 | 2 | 2 | 2 | 2 | 2 | 2 |
| Stakeholder 5 | 1 | 1 | 2 | 1 | 1 | 1 |
| Stakeholder 6 | 1 | 1 | 2 | 1 | 1 | 2 |
| Stakeholder 7 | 2 | 2 | 2 | 2 | 2 | 2 |
| Governmental organizations | | | | | | |
| Stakeholder 8 | 1 | 1 | 2 | 1 | 1 | 2 |
| Stakeholder 9 | 1 | 2 | 2 | 1 | 2 | 2 |
| Stakeholder 10 | 1 | 2 | 2 | 1 | 2 | 2 |
| Stakeholder 11 | 1 | 1 | 2 | 1 | 1 | 2 |
| Non-governmental organizations | | | | | | |
| Stakeholder 12 | 1 | 2 | 2 | 1 | 2 | 2 |
| Stakeholder 13 | 2 | 2 | 2 | 2 | 2 | 2 |
| Stakeholder 14 | 1 | 1 | 1 | 1 | 1 | 1 |

Score meaning: 1—stakeholder is promoting sustainable systems/diminishing unsustainable systems; 2—stakeholder is definitely promoting sustainable systems/diminishing unsustainable systems.

Stakeholders that have been evaluated as "2" are definitely promoting sustainable systems/diminishing unsustainable systems, and GT is one of their core activities. This information can be found in stakeholders' vision, mission, and their daily activities. Stakeholder 1 and Stakeholder 2 are presenting private organizations and both these companies are working towards GT. For example, Stakeholder 2 is the first company in the EU that connected the manufacturing of bioethanol (base of biofuels), electricity and thermal energy sources into one uninterrupted technological loop. This technological loophole not only produces zero waste but also the valuable organic fertilizers that are becoming increasingly in demand in contemporary farming.

Research organizations, such as Stakeholder 4 and Stakeholder 7, have a long-standing history in agricultural, biogas and related activities, where innovations, circular economy, eco-friendly and climate-neutral aspects are core functions of these institutions.

As the European Green Deal and GT are becoming increasingly important discourse and core strategies on the EU level, public institutions must adapt to these changes. In the Lithuanian case, governmental organizations (Stakeholders from 8 to 11) such as the Ministry of Environment, the Ministry of Energy, the Ministry of Economics and Innovation and the Ministry of Agriculture are key institutions in implementing these strategies towards GT, and their role is getting even more important because a lot of new measures are needed to be implemented in near future.

Non-governmental organizations are also a very important aspect of GT in Lithuania in both promoting sustainable systems and diminishing unsustainable systems. Stakeholder 12 and Stakeholder 13 are advocating for cleaner, safer and more sustainable living conditions. Both organizations are important actors on national and local levels, especially in uniting and representing their interests towards deeper GT.

#### 3.1.3. Stakeholders' Influence on Niche, Regime, and Landscape Level

Private organizations are affecting niche and regime level, but the influence from the previous 5 years until the next 5 years will remain similar. The influence of governmental organizations on GT for the biogas sector in Lithuania is increasing, comparing the previous 5 years, the current situation and the next 5 years from having an influence to having a definite influence on all three levels: niche (product level), regime (national level) and landscape (the EU) level. This is in relation to the increasing role of GT in the EU and national legislation that needs to be implemented in the legislation system and leads to the national and the EU support mechanisms. Research organizations have greater influence on the niche (product) level, and this influence is expected to grow in the future. NGOs have an influence on the niche (product) level and this influence is expected to increase in a 5-year period.

Detailed results on stakeholders' level of influence are provided in Table 5.

**Table 5.** Stakeholder's level of influence for biogas production from manure and agro wastes in Lithuania.

| Type of Stakeholders | Affecting Niche (Product) Level | | | Affecting Regime (National) Level | | | Affecting Landscape (EU) Level | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 Years Ago | Now | in 5 Years | 5 Years Ago | Now | in 5 Years | 5 Years Ago | Now | in 5 Years |
| Private org. | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.3 | 1.7 | 1.0 | 1.3 |
| Governmental org. | 1.5 | 1.8 | 2.0 | 1.5 | 1.8 | 2.0 | 1.5 | 1.8 | 2.0 |
| Research org. | 1.8 | 1.8 | 1.8 | 1.3 | 1.3 | 1.8 | 1.3 | 1.3 | 2.0 |
| NGOs | 1.7 | 2.0 | 2.0 | 1.7 | 1.7 | 1.7 | 1.0 | 1.0 | 1.0 |

Scale from 0 to 2 to evaluate the relevance of stakeholder: 0 = Stakeholder does not have influence on niche, regime and landscape level; 1 = Stakeholder does have influence on niche, regime and landscape level; 2 = Stakeholder definitely does have influence on niche, regime and landscape level.

In general, all four key groups of stakeholders on all levels—niche, regime, and landscape—will have a tendency to increase their influence in comparison to 5 years ago,

now and in 5 years. *For the niche level*, the biggest increases are expected for governmental organizations, with an 11.1% increase comparing the current situation and the situation in 5 years (from 1.8 to 2.0). Private organizations and research organizations are stable, with figures of 1.7 and 1.8 for a 10-year period (5 years ago, now and in 5 years). The non-governmental organizations' biggest increase was comparing the current situation and 5 years ago (increase of 11.8%, from 1.7 to 2.00). *For the regime* level, the biggest change is also planned for governmental organizations, with an 11.1% increase comparing current situation and the situation in 5 years (from 1.8 to 2.0). Private organizations' influence will decrease from now to 5 years (decrease of 30.8%, from 1.7 to 1.3). Research organizations' role for GT will increase in 5 years, by 38.4% comparing the current situation with the situation in the coming 5 years (from 1.3 to 1.8). *For the landscape level*, significant change is predicted for research organizations, with figures of 1.3 five years ago to 2.0 in 5 years starting from today's perspective (50% increase). The private organization's role is also planned to increase from today to a 5-year perspective from 1.0 to 1.3 (33.3% increase). An increase is planned for governmental organizations, with an 11.1% increase comparing the current situation and the situation in 5 years (from 1.8 to 2.0). Non-governmental organizations' figures are stable, with figures of 1.0 for a 10-year period (5 years ago, now and in 5 years).

### *3.2. Pathway towards GT in Biogas Sector from Manure and Agro Wastes in Lithuania*

A potential pathway for GT for biogas production from manure and agro wastes in Lithuania was identified based on the results of the interviews with selected respondents. Interviews had been conducted from March to April 2021. The five potential pathways for GT, described in the introductory part of the article (see Section 1), were introduced to respondents.

All respondents have selected the second option as a pathway for GT in Lithuania, i.e., regime transformation, which is understood as the change through adjustments of existing industries, skills, regulations and institutions, seems to be most suitable for the existing state of the GT. Regime transformation was selected for other alternatives since there is no possibility to prepare employees and specialists promptly.

Some of the other respondents (60%) have mentioned more pathways, such as technological substitution, regime reconfiguration, and de-alignment and re-alignment. None of the respondents (0%) have chosen the last suggested pathway, i.e., institutional exhaustion, stating that GT will be blocked due to intense conflicts, and industries will react to macro-level pressure through protests and downscaling. It was marked that none of the stakeholders will not support this option, since it is unrealistic for the Lithuanian case, and even for the overall GT more broadly.

To conclude, rapid changes are difficult to implement because of the need for specialists, innovations and knowledge. Because of this, public authorities and decision-makers must plan accordingly, and the pathway for GT must be prepared with supporting strategic documents. Moreover, it should be noted that, for regime reconfiguration and de-alignment and re-alignment, skillful and innovative specialists should be prepared, and therefore the state must contribute to the transformation of the regime through education, taxes, audits, labeling, etc.

*Initiatives for a pathway for GT.* Respondents were asked to assess whether top-down (landscape) principles, bottom-up (niches) principles or both are dominant. At its current state in Lithuania, the most promising pathway covers both ways, combining the top-down (landscape) and bottom-up (niches) approach. As Lithuania still is a moderate innovator, the top-down acceleration might be significant in terms of a more rapid movement towards urgent solutions in the biogas sector, which would update and innovate the outdated areas and fields of activity. The bottom-up actions naturally happen if a favorable environment will be created for the development of GT focused solutions. First, an essential role in this combination is played by knowledge and education regarding the issue. Secondly, financial injections and support are necessary to make the pathway act. The research revealed that

the transformation is not available only on a voluntary basis. Therefore, the funds should be allocated transparently and systemically, to reach the actual and desired GT. So, the trust, responsibility, and transparency are the crucial factors for seeking a successful step forward.

*The role and significance of the national level.* Respondents have mentioned that the role of the regional level in the GT should be necessarily enhanced. Currently, non-governmental organizations, representing local communities, expressed their concerns that they are not heard enough and that there is a huge gap in communication between national, regional, and local levels. At the same time, the local level is the crucial implementer of very simple everyday activities, which might correspond to GT, but which are currently impossible due to the legislative restrictions and related shortages of measures applied at the regional level.

*Major risks and uncertainties.* Several risks and uncertainties were identified by respondents, especially by the private organizations. The private sector is concerned about new requirements towards GT when there is not enough time given to adapt and implement greener technologies. Because of this reason, governmental organizations see that they can become uncompetitive compared to other players in the field. Another risk is more related to the state funding—the private sector expressed their concerns towards transparent allocations of national and the EU funds, as they see that still there is some overindulgence from both the private and the public sectors. At the local level, the greatest observed risk is an immense gap of knowledge and education regarding the overall conception of GT, especially in the field of circular bio-economy. During the interviews, another risk had been outlined concerning misunderstanding of the basic terms and issues due to limited knowledge, caused by the lack of information and literature in a national language. This is very specific to the senior generation and remote rural regions.

*The need for new activities and actors* to enhance the GT. Different stakeholders agreed on the several new activities that would give more understanding in diverse points of view towards the GT. Interviewees stressed better horizontal cooperation, a wider activity within and throughout the relevant networks, especially considering the role of decision-makers, as well as different stakeholders from helixes. Such activities could increase the trust and better elucidate the value of communication, thus leading to greater ambitions in GT goals. Another concern outlined during the interviews was a lack of actors as professionals with higher education, who are familiar with necessary activities to be taken by private organizations and policy levels to make the genuine GT happen. Unfortunately, Lithuanian employers still do not recognize such professionals in the market and often look for such professionals abroad. Normally, foreign professionals are expensive, and, moreover, they are not familiar with Lithuania-specific environments, which greatly shape the actual implementation of GT. Thus, the local professionals should be on-demand to make appropriate solutions for today's industry and policy concerning the GT.

Another action proposed by some respondents is related to education and learning activities on GT. For example, one of the biggest Lithuanian technical universities had already included sustainability as a compulsory course in all study programs. Similar actions should be performed by other players in the field of education and science, because education concerning the sustainability phenomena and the conceptions of bio and circular economy is relatively poor in terms of the level of general knowledge on the issue, and this disturbs further developments for GT in Lithuania. Lack of knowledge regarding these issues, as stated by experts during the interviews, is a common feature of all levels and all stakeholders: policymakers (national and regional), businessmen (small to large-scale, all sectors), academia (which is not involved/connected to the issues of sustainability, smart specialization, etc.) and citizens.

*Role of technologies and technological substitution.* Respondents also have highlighted the role of technologies. The support of the EU plays an important role, as it can act as a helpful catalyst for innovation. As companies may not be ready and willing to make new investments, such as new technologies, and the process of GT can come to a standstill, the EU and national support would encourage faster implementation of GT activities.

## 4. Conclusions

The future of GT in Lithuania primarily depends on education, on a similar understanding of the phenomenon of GT and related concepts. A crucial role in Lithuania concerning the issue is to be played by the younger generation, whose education entails elements and systems of GT aiming to create common, grounded understanding and overall support.

The research results demonstrate that the key actors identified in fostering GT are governmental organizations, leaving NGO, business and research organizations behind. Governmental romanizations' core responsibility is to prepare strategic long-term planning towards the GT that would lead to flexible implementation of innovations for private organizations, non-governmental organizations, and other related actors. Would they be able to become a definite stakeholder for GT in Lithuania? What tools can they already employ to speed up this process?

First, Lithuania can speed up the GT process with properly setting a long-term vision of the overall country's GT alongside the strategic goals covering all sectors, policies, and public institutions, and accordingly allocating investments.

Secondly, the governmental organizations should support initiatives based on a bottom-up approach that can take a leading position to speed up this process in Lithuania. For better results, demonstration models as a tool for the implementation of GT in their business/activities should be proposed. The actors should be grouped according to appropriate criteria (small, medium, a large type of business, etc.), aiming to meet the needs of each group. There is a need to draw attention and motivate those who do not know how to implement GT and to demonstrate good practice examples.

Finally, education had been recognized as the key tool for the GT in Lithuania. High demand for education concerning the GT was observed both considering the age and the sector criteria. It is thought that the GT must become a "new normal" not only to those who are working on the issue or are directly involved in GT but to the whole society. It is a new reality where we live, i.e., all stakeholders and the society as a whole need to learn how to live in harmony with nature and to be a climate-neutral society because there is no planet B.

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