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Knowledge Translation and Its Interrelation with Usability and Accessibility. Biocultural Diversity Translated by Means of Technology and Language—The Case of Citizen Science Contributing to the Sustainable Development Goals

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Abstract: Translation plays an important role in all areas of human activity. Despite its primary role of overcoming language barriers, it is used as an analogy for activities that require transfer, mediation, or negotiation of meaning. Knowledge translation is a concept that links knowledge to action, which is also at the heart of citizen science. Several studies have highlighted the ways in which citizen science can contribute to the definition, monitoring and implementation of the United Nations' Sustainable Development Goals (SDGs). Although these studies emphasized the importance of data contributions for SDG reporting and monitoring purposes, this paper applies the concept of knowledge translation to citizen science for achieving the SDGs based on the conceptual framework provided by translation studies. Knowledge translation, citizen science, and the SDGs have their focus on actions and negotiations in common. Citizen science can, thus, be regarded as a mediator between science and the SDGs or a mediator between the public and policymakers. Exemplified by biocultural diversity, this paper analyzes the application of knowledge translation to the SDGs in and through citizen science. Citizen science guided by the SDGs requires different forms of knowledge ((and) translation) that are usable, accessible, and meaningful.

Keywords: translation; knowledge; citizen science; SDGs; knowledge management; knowledge co-production; knowledge transfer; biocultural diversity; terminology

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1. Introduction

Citizen science has enjoyed growing popularity recently, especially regarding the various ways it may contribute to the United Nations' Sustainable Development Goals (SDGs). Since citizen science has at its core the collaboration between academics and members of the public, who (voluntarily) contribute to an academic endeavor, the notion of "translation" refers to different phenomena within citizen science projects. Translation is used here in its broadest sense, referring to translation of knowledge, translation of the language of science into generally comprehensible language, translation of theory into practice, and many more.

Additionally, many forms of citizen science rely on the use of technology, e.g., an app with which participants can upload and analyze pictures or a web-based platform on which participants can analyze or transcribe data. Therefore, the usability of these apps and platforms (for a diverse range of users and not only specialists) plays a crucial role in citizen science. However, usability may also refer to the usability of the project outputs, including the data gathered and analyzed or the project results in general (for different purposes).

Moreover, the claim "leaving no one behind", which is stated several times in the 2030 Agenda [1], shares similarities with inclusion and accessibility that are of increasing interest also in citizen science: especially engaging the "hard-to-reach" or aiming at equity, empowerment, and inclusion. Here, the question of "who is excluded?" from citizen science in general or from a specific project, is raised. This debate is related to inclusion and, therefore, also to accessibility.

1.1. Usability

In the following section, the terms usability and accessibility are briefly explained based on related ISO standards. However, the definition and scope of usability and accessibility are far more elaborately discussed in the literature, which is beyond the scope of this paper.

Usability is defined as the "extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [2]. Therefore, the special constellation of users, their goals and the relevant context in which they use the relevant system, product, or service is crucial when addressing usability. In the case of citizen science, the systems are often used by both the researchers and the participants. This also means that the users do not have the same background knowledge and experience since academic platforms or programs are often designed for a very narrow, and highly specialized user group. Thus, scholars and citizen science participants have different needs and expectations which makes finding a one-size-fits-all technological solution difficult.

Recruiting and retaining participants in citizen science projects is a hard-enough challenge. Therefore, the risk of losing them in the recruitment process or over the duration of the project due to the bad usability of technological systems should not be underestimated. This may be one of the reasons why the topics of technology and the related usability have received considerable importance in the citizen science literature. In the Journal of Science Communication special issue on User Experience of Digital Technologies in Citizen Science in 2019, the authors addressed a wide range of technology design issues: user experience, virtual citizen science as a sociotechnological system, a systematic literature review, digital user feedback, game interface aspects, online practices of professionals and amateurs and digital platforms for cultivating attachments to nature.

1.2. Accessibility

Accessibility is the "extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of user needs, characteristics and capabilities to achieve identified goals in identified contexts of use" [2].

Although the term accessibility is often used in the context of accessibility for people with disabilities or impairments, this definition demonstrates that accessibility is strongly related to universal design (design for all) that states that the design of a product, system or service needs to include as many potential users and as many potential uses as possible already from conception [3]. This means that a product, system, or service should not be made accessible for e.g., people with physical, auditory, or visual impairments or cognitive impairments afterwards, but should be accessible already by design.

Accessibility, thus, ranges from physical spaces, such as buildings, and media, such as television to digital technologies. This also demonstrates that the application of assistive technology to already existing products should not be the main way to go but rather a design that can be used by (almost) all people in the first place.

Barriers to accessibility can lead to frustration and exclusion (and marginalization) [4]. Since citizen science invites everybody to engage in research themselves and, thus, follows a rather inclusive approach, accessibility is an issue that should be addressed already from the very conception of a citizen science project.

Another meaning of accessibility may also refer to access, e.g., access to information, access to data, access to project results, etc. This notion of accessibility clearly links to citizen science and the SDGs, and especially to data and information needed to measure the achievements of the SDGs by means of the SDG indicators, which will be elaborated below.

In citizen science projects, we usually find a combination of the objects mentioned in the definition of accessibility above, namely products, systems, and services in a variety of forms. These may include a project website, interactive maps on the website, video tutorials for data gathering or data analysis as well as training material.

1.3. Citizen Science and the SDGs

The United Nations 2030 Agenda for Sustainable Development consists of 17 SDGs, 169 targets, and related SDG indicators. It is a universal plan of action that addresses sustainable development in three dimensions, i.e., the environmental, economic and social dimensions and targets all countries and stakeholders to take actions and policies towards a resilient path for the planet and humanity. Therefore, the SDGs cover a diverse range of issues ranging from poverty, hunger, health, well-being, peaceful and inclusive societies, education, inequality, gender, production and consumption, urbanization, climate change, environment, and several ecosystems and natural resources [1].

The SDG indicators serve the purpose of monitoring the progress in achieving the SDGs. Data for these indicators are mainly sourced from databases maintained by national statistical offices, international organizations, or governmental bodies.

To date, several studies have highlighted the role of citizen science in promoting, supporting, and achieving the SDGs. Citizen science can contribute to data for SDG reporting and monitoring purposes. Some authors [5] found that citizen science already contributes to the monitoring of SDG indicators, with a strong focus on SDGs in the environmental domain. The authors argue that citizen science could actually contribute to 76 indicators, i.e., a third of all indicators.

This is confirmed by an earlier study [6] highlighting the potential of citizen science to advance the three categories of defining, monitoring, and implementing the SDGs. First, citizens can help define and refine SDG elements. Although the targets and the indicators seem to be set in stone, there is still room for further refinement and for specifying targets in a way so that they have more significance for a person's lived experience. For example, SDG Target 7.1 which aims at ensuring "universal access to affordable, reliable and modern energy services" provides room for interpretation when applying it to a certain context. Citizen science could help define criteria for affordability since it depends on various objective and subjective factors that are different for different groups. Here, citizen science could help finding more relevant indicators. Additionally, what is perceived as "modern" may vary between citizen groups. Citizen science may also help define reliability, which may be relevant for groups of persons whose situation may not be covered well by the targets or indicators. If citizens have a say in the development of national targets within the SDG framework, their national governments may be more inclined to meet them since the citizens may hold their government to account. Second, citizen science can support monitoring efforts (as described above). Data that are needed to measure the progress in the SDG process may be collected by citizens. This includes data for filling data gaps that the national statistical offices identify. Moreover, if citizens gather data themselves, this can help increase transparency and accountability. Third, citizen science can contribute to the implementation of the SDGs. Especially on the local level, the stories of citizens can be persuasive means for acquiring funding or triggering actions locally. This may range from raising awareness for an issue and educating or inspiring participants to changing their behaviors and attitudes. They may even develop a sense of ownership and willingness to search for a solution. They may become activists or stewards for change needed to achieve the SDGs. Citizen science may also be a hub for engaging citizens in decision-making. Moreover, SDG 17 aiming at global partnerships can be supported with citizen science by fostering partnerships between different stakeholders, including civil society, the state, academia, or business. This may support knowledge sharing, collaboration and capacity-building [6]. Additionally, citizen science can help to tap non-traditional sources of data [7].

The inclusion of members of the public in the definition, monitoring and implementation of the SDGs aligns well with the Agenda 2030 that recognizes the "different approaches, visions, models and tools available to each country, in accordance with its national circumstances and priorities, to achieve sustainable development" [1], since this gives countries the possibility to make local adaptations. These local adaptations, which are known as localization in translation studies, are at the heart of translation.

This shows that citizen science can contribute data to increase or enhance statistical data coverage, or even fill data gaps (where little or no (recognized) data sources exist), for the purpose of the SDG indicators. In some areas, citizen science already contributes data to the SDG indicators, such as in the fields of biodiversity and conservation. Additionally, citizen science also holds potential for the methodological developments for SDG indicators. Moreover, citizen science may develop additional goals and targets to fill existing gaps, such as in the case of air-quality monitoring [7]. Other authors' [5] vision is a science-driven approach that does not only consider citizen science in the monitoring of the SDGs but places it at the very center. Further promises that citizen science holds are providing members of a public a means for informing policy. This may raise trust in the monitoring process for achieving the SDGs. Furthermore, data collection and research may offer opportunities for citizen action. Since the SDGs require societal transformation, also decision-making structures in politics, economics and society in general may need shifts resulting in changing the basis for decisions and the interactions with the public. Citizen science partnerships can thus support the progress in achieving the SDGs.

Several papers that link citizen science and the SDGs show a clear connection to accessibility and usability as well as knowledge transfer. For example: "Clear guidance and usable tools need to be offered to citizen science projects to make their data available and fit-for-use within the SDG framework" [7]. Here, accessibility and usability are reflected in interoperability requiring (metadata) standards, such as the data and metadata standard for Public Participation in Scientific Research (PPSR) and the FAIR (findable, accessible, interoperable and re-usable) data principles [7].

This demonstrates that citizen science that is guided by or contributing to the SDGs can achieve tangible outcomes. However, it may also have "intermediary" value or impact that is hard to trace. This can range from engaging in broader discussions that are mutually beneficial for all persons involved and change on an individual level.

These promises, claims, and endeavors are supported by various networks, partnerships and initiatives, one of these being the Citizen Science Global Partnership. Moreover, during the Citizen Science SDG Conference in October 2020, the Declaration entitled "Our world—our goals: citizen science for the Sustainable Development Goals" was published as a social contract endorsed by various stakeholders to highlight the potentials of citizen science in advancing the SDGs. It lists three recommendations for linking citizen science to the SDGs, including the recommendation of harnessing the citizen science benefits for the SDGs, strengthening citizen science and its links to other communities as well as strengthening citizen science systems in the future [8].

1.4. Translation

Translation plays an important role in all areas of human activity, ranging from economy and governance to literature and culture [9]. "Translation lies at the heart of communication, understanding, and compassion, between different language cultures, communities, and individuals" [10]. A traditional definition of translation is the transfer (of meaning) of a text from a source language into a (text in the) target language [11]. Translators do not translate words or languages, but texts. Texts are embedded in a certain situation that is determined by historical, cultural, and socio-economic aspects. Therefore, translation can be regarded as an intercultural process of transfer or interaction that is determined by its purpose (skopos) [12]. The intended purpose of the target text influences the realization of content, form, style, perception, etc. of the translation. Nevertheless, the purpose of the source text may be different from the purpose of the target text.

Therefore, translation is a process that "involves complex negotiation between languages" [13]. This demonstrates that languages are not identical, i.e., there is no 1:1 equivalence between languages, since they usually do not have the same syntax, lexis, etc. Therefore, translation requires adjustments for which the translator must interpret the source text and reformulate it in the target language [13]. Translation is thus a balancing

act between the fidelity to the original and/or the author of the original text and freedom, i.e., the extent a translator can diverge from the original [13].

Translation is a means to overcome language barriers and culture barriers. Therefore, it is also referred to as a combination of linguistic and cultural transfer [14]. Especially the notion of "transfer" is an essential idea in the knowledge translation discourse, which will be elaborated on in more detail in the next section.

Metaphorically speaking, translation and interpreting are also described as mediation [15] or building bridges, etc. This means that a translator is constantly negotiating linguistic and cultural difference [13].

Translation also means getting the message across. Since some areas of the academic discourse on translation center on the equivalence (of meaning) between the source and the target text, the fidelity to the author of the source text or fidelity to the purpose (skopos) of a translation are key when deciding on translation strategies. This skopos, that is the basis for the translation strategy, is also crucial for knowledge translation and the translation of the SDGs into actions.

Translation is often used as analogy or metaphor in various contexts. For example, interdisciplinarity or transdisciplinary work is considered a task of translation since the tensions or differences between disciplines must be addressed and a common understanding must be defined. In interdisciplinary projects it is important that the participants "speak the same language". Related to terminology, disciplines often impropriate concepts used in other disciplines. Through this transformation in other contexts and contact with other concept systems, they may be re-defined [16].

In addition to translation between disciplines, translation (studies) offers various methods and approaches that may enrich the methodology of other disciplines. A so-called translational approach considers differences, mediation, contexts, cultures, connections, etc. as a "border thinking" or "in-between thinking" [16]. As part of the translational turn, translation does not (only) follow the ideal of building bridges between cultures or enabling cultural understanding, but it is a methodological approach that helps negotiate differences, evaluate and re-evaluate misunderstanding and reveal power asymmetries [16].

1.5. Knowledge

Knowledge is key for governance and guidance in a society as well as societal success and progress [17]. Studies in the field of knowledge management stress that localized comprehensive knowledge is the basis for actions of individuals and organizations that drive societal advances. However, to seize this knowledge, persons need the competences to do so.

Although knowledge is seen as driver of growth and new employment opportunities, it can also be a driver of (societal) change as envisioned in the SDGs and as implemented by citizen science.

1.5.1. Types of Knowledge and Knowledge Transfer

To differentiate knowledge from information and data, a hierarchy from data to information to knowledge to wisdom was introduced [18]. Data that are purposefully selected and organized become information. Information that is understood and applied to actions in context becomes knowledge.

There are different forms of knowledge and some forms of knowledge may be more suitable for tackling certain challenges than others. Knowledge can be personal, shared, embedded (in artefacts) or part of a society's or organization's culture. Knowledge is often created through the collaboration between different actors. It serves different roles, ranging from awareness creation (seeing things from several perspectives), sense making, problem-solving, decision implementation (taking actions according to the decisions) and governance (to monitor actions) [17].

Knowledge can take various forms, ranging from knowledge-as-object, implicit knowledge, knowledge-as-process to tacit knowledge, or meta-strategic knowledge. Knowledge-

as-object is explicit knowledge that can be observed and inspected. Usually, it is circulated as information and can be included in documents or stories. Explicit knowledge, thus, can be accessed and used without the knowledge creator since it is codified or communicated in a symbolic way or natural language. Implicit knowledge is only accessible through the analysis of documents or stories. Knowledge-as-process originates from people or organizations tackling unusual challenges that require the application of tacit knowledge and seek explicit knowledge, thus, learning from the process. While working towards a common goal, people collaborate to find a solution. Tacit knowledge takes the form of knowledge embedded in human minds and can be hardly explicit. It is part of perceptions, values, beliefs, perspectives, traditions, practices, and motivations. Tacit knowledge can only be accessed through continuous engagement with the holder of this knowledge. Meta-strategic knowledge is part of metacognitive knowledge. It provides metacognitive perspectives that govern the attitude by which a person or an organization approaches complex challenges. Meta-strategic knowledge is the basis for a person's or organization's mentality towards challenges. Here, prior experiences shape risk-averse or risk-taking behavior [17,19].

These different forms of knowledge are transferred through various modes, such as general education, everyday work, collaboration, communities of practice, networks, or best practice. The means of obtaining these forms of knowledge include texts, reports, presentations, procedures, work artefacts and products, stories, practices, activities of problem-solving and explaining, discussions, hands-on learning, reflections, and understanding [17]. Therefore, knowledge management is an essential element within organizations (and societies).

1.5.2. Knowledge Management and Knowledge Management Tools

Although the focus of this paper is on the aspect of knowledge translation (which will be explained in the next section), it is important to differentiate knowledge translation from knowledge management. There is no common definition of knowledge management. However, in this paper knowledge management refers to "identifying and leveraging the collective knowledge in an organization to help the organization compete" [20]. Although this definition has a clear focus on organizations and the management of activities related to knowledge such as the creation, organization, sharing and use of knowledge to create value [21], this paper extends this definition beyond organizations.

Additionally, the knowledge process (in an organization) can be subdivided into different phases. For example, we may differentiate between four knowledge processes: knowledge creation, knowledge storage and retrieval, knowledge transfer, and knowledge application. These phases focus on combining an individual's practices and cognition with collective culture and practices. First, knowledge creation means to prepare novel content or substitute previous content as part of the organization's explicit and tacit knowledge. Both collaboration and cognitive processes of individuals allow for knowledge creation and sharing. This means that tacit and explicit knowledge are constantly intertwined. Knowledge moves through individuals and groups and within an organization. Second, knowledge storage and/or retrieval means that knowledge should be stored and be retrievable since it resides in written documentations, databases, expert systems, documented organizational processes as well as individual tacit knowledge and networks. Third, knowledge transfer occurs at different levels. Knowledge is transferred between individuals, from individuals to explicit knowledge sources, from individuals to groups or between groups, and from groups to the organization at large. Within an organization, knowledge must be transferred to those units or persons that need it and can use it. Communication and information processes facilitate this transfer. Fourth, knowledge application is considered the essential phase since knowledge is useless unless it is being applied. This refers to the conversion of the tacit knowledge of specialists to integrated and explicit knowledge required for efficiently communicating with non-specialists. This also means

that specialized knowledge can be applied without having to consult the knowledge holder directly [20].

Also, knowledge-related strategies revolve around these processes, such as the knowledge creation strategy or the knowledge transfer strategy. The knowledge creation strategy puts an emphasis on learning, research, and development and the motivation to innovate. The knowledge transfer strategy, on the other hand, concentrates on the systematic transfer of knowledge to locations of actions at which knowledge is used for performing work. Thus, knowledge transfer, according to this model, encompasses the steps of obtaining, organizing, restructuring, memorizing, repacking for deployment, and distributing knowledge. Here, the sharing of knowledge and the adoption of best practices play a crucial role [22].

The knowledge process or knowledge management may also be supported by technology. Therefore, knowledge management and knowledge management systems go hand in hand. Different notions of knowledge management systems exist. Knowledge management systems can either be knowledge management practices, i.e., a set of techniques and methods supporting organizational processes related to knowledge, including knowledge creation, knowledge storage, knowledge transfer, and knowledge application. On the other hand, knowledge management systems can be information technology-based systems that support these knowledge management techniques and methods [19].

Each of the phases mentioned above may, thus, be supported by information technology. For example, knowledge creation may rely on content management systems, blogs, or data analysis. Knowledge distribution can be facilitated with knowledge repositories, internet and intranet networks, cooperation tool, wikis, online forums, or video conferencing tools that allow for knowledge sharing and give access to information about projects. Knowledge usage can be enhanced through pattern matching tools that give quick access to useful data [23]. Basically, information technology used for (organizational) knowledge management has three applications, including sharing and coding best practices, creating knowledge directories and establishing knowledge networks. These three applications either focus on mapping expertise, benchmarking or enabling exchange between experts to share and increase knowledge [20]. These help to make knowledge accessible. However, all these tools require user acceptance [24], highlighting the significance of usability and accessibility of knowledge management systems.

Now turning back to the knowledge processes of creation, storage/retrieval, transfer, and application, these can be subsumed under "knowledge translation".

1.6. Knowledge Translation

The term "knowledge translation" is widely used in health sciences and refers, in its broadest sense to "the process of putting knowledge into action" (knowledge to action) [25], and in a narrow sense to the World Health Organization's definition: "the synthesis, exchange and application of knowledge by relevant stakeholders to accelerate the benefits of global and local innovation in strengthening health systems and advancing people's health"(Pablos-Mendez A, Shademani R., 2006 cited in [26]). Other terms used are implementation science, dissemination, and diffusion, research use and knowledge transfer and uptake [25]. The commonalities of these terms are that they go beyond the dissemination of knowledge, e.g., publication of research findings in journals or through presentations. They address the actual use of knowledge (in decision-making) [25]. Related concepts are knowledge transfer and knowledge exchange. Although knowledge transfer is rather unidirectional, knowledge exchange is often considered to be mutual.

Interestingly, the existing body of translation studies research hardly addresses knowledge translation and the same holds true for the citizen science literature. However, translation is an appropriate analogy for knowledge management, knowledge transfer, and knowledge exchange as well as linking knowledge and practice. Studies [27] describe knowledge transfer as translation and argue that knowledge transfer is a rule-based translation process. The translation strategy is crucial for the final outcomes of processes that

can be referred to as knowledge transfer. From the perspective of organization research, variables in knowledge transfer processes are the translatability of the source (practice), the transformability of the knowledge transferred and the similarity between the sender and recipient (units).

Knowledge itself is conceptualized differently in different disciplines, ranging from constructed knowledge, created knowledge, embodied knowledge and collectively negotiated knowledge [26]. The translation analogy is also used in the knowledge transfer literature to describe the process of knowledge transfer based on the ideas that translation is a networked activity, rests on process and end-product quality, defines levels of accuracy and the idea that there are constraints to the generation of good translations [28]. Regarding the networked activity, translation is embedded in a network of social relations, as is knowledge transfer that also depends on networks of receivers of knowledge. From the translation studies perspective on process and product quality, knowledge transfer can derive aspects of quality assessment for both the process and the product. Concerning the levels of accuracy, in knowledge transfer processes the sender must convey appropriate information to enable receivers making sense of this information. Similar to translation, which is often restricted in time or the availability of resources, knowledge transfer also faces constraints and barriers [29].

In addition, knowledge translation can also mean the translation of knowledge from one language into another language. Since scientific works are carriers of knowledge, their translation furthers scientific advancement and spreads knowledge in new circles [10]. Conversely, this also means that if no translations are available, information and knowledge remain within the boundaries of a nation, region, or language community. This knowledge may be even lost for posterity if there are no (written or audio) records of this knowledge.

2. Materials and Methods

The objective of this study is to investigate the role of knowledge translation in citizen science supporting the SDGs, thereby highlighting the aspects of usability and accessibility. This analysis is based on the conceptual framework provided by translation studies, from which the process of knowledge translation in citizen science regarding the SDGs is discussed.

The conceptual framework in this study is derived from the functionalist approaches in translation studies. Functionalist approaches assume that translators always consider the purpose (skopos) of the text in the target language. They select their translation strategy and make translation decisions according to this skopos. This skopos may require the adaptation of the target text to the cultural conditions in the target locale [30,31].

It is important to bear in mind that the term "culture" is not restricted to human literature, theatre, and music, but encompasses the entirety and combination of societal experience, thinking patterns and practices that characterize the behavior of a society or group [32]. This means that culture includes customs and behavioral patterns, conventions, norms, and beliefs. Culture grew over generations based on (collective) experience. Members of different cultures have different knowledge of the world due the fact that they give different priorities to phenomena in the(ir) surroundings [33]. Although cultures offer some stability, they are no unified givens. They are subject to constant change which arises from "multifarious overlaps, transferences and histories of entanglement within the uneven power relations of world society" [16]. Depending on the definition, culture may encompass the entire spectrum of human activities. However, culture may also be used to refer to conventions, habits, and norms within a smaller framework, such as when referring to the "culture of a discipline" or the "culture of an organization".

The second aspect of this conceptual framework, in addition to the functionalist approaches found in translation studies, is the concept of "language" since translation was introduced as the transfer of meaning between two different languages. A language is a means that reflects the way of seeing the world. This means that people may interpret the experience of reality differently in another language. This diverging interpretation of

reality may be a completely novel way of seeing the world for members of other language communities. This also entails the use of other designations for this experience of reality. Therefore, language and culture offer manifold forms of referring to reality, and, thus, manifold ways of interpreting it. Our experience helps us to decipher the meaning [32]. Language is subject to continuous change to allow for the flexibility that is required in human communication to describe related social and cultural requirements [34].

As mentioned in the introduction, the transfer of meaning is essential in knowledge translation and this transfer is often made by means of language. Therefore, this study, being theoretical in nature, combines the insights gained from functionalist approaches in translation studies with the aspects of knowledge translation in and through citizen science and sets these into the broader context of the SDGs.

Although previous academic literature highlighting the potential of citizen science to contribute to the SDG framework rather focused on the provision of data for individual SDGs and on educational gains, this study outlines the future potential of citizen science and the role it can play in reaching the SDGs by applying the concept of knowledge translation to citizen science and the SDGs. This is exemplified by biocultural diversity (knowledge) that is "translated" by means of language and technology.

3. Results and Discussion

3.1. Consolidating Translation, Citizen Science, and the SDGs

Knowledge translation, citizen science, and the SDGs have several aspects in common, especially the focus on actions (Table 1). Knowledge translation which is also referred to as the process of "know-to-action" aims at bringing knowledge to action. Citizen science invites participants to act in and for academic research and the SDGs are "A call for action to change our world". Additionally, the concepts of knowledge translation, citizen science, and SDGs have knowledge at their heart.

Table 1. Comparison of knowledge translation, citizen science, and the SDGs.

	Knowledge Translation	Citizen Science	SDGs
Action	Bringing knowledge to action	Increasing, gathering, transferring knowledge	SDGs are "plan of action for people, planet and prosperity" and "a call for action to change our world"
Social change	Improving life of users of knowledge (or persons affected by knowledge)	Opening up academia, considering new perspectives; Cooperation among different actors (for a greater good)	Transforming the world (as the title suggests)
Translation	Mediation between knowing and doing; Negotiating knowledge and action	Translation proper; Mediating academic and public knowledge and culture; Localizing knowledge and material; Speaking the language of participants	Translation proper; Understanding the SDGs; Fostering mutual understanding (between cultures); Putting SDGs into action; Operationalizing the SDGs through the SDG indicators
Differences	Negotiating the difference between culture of knowledge holders and culture of persons affected by knowledge	Negotiating the difference between culture of academia and culture of participants	Negotiating the difference between culture of policymakers and culture of members of the public
Power	Tension between knowledge acquisition and knowledge application	"Forcing" scientific worldview on groups of people; Empowering participants	Tension between what is considered to be source for the SDG indicators

Moreover, social change and societal transformation are inherent in all of them. Knowledge translation aims at improving the life of the knowledge users or persons affected by

knowledge, citizen science itself has transformative potential as it opens up academia, and the monitoring of the SDGs relies on the SDG indicators, which do not only require data but also knowledge (to gather and interpret them).

Translation is a negotiation, a balancing act trying to mediate between two languages and their cultures and doing justice to either the author of the source text or the reader of the target text, or both. This is also true for knowledge translation that aims at striking a balance between knowing and doing, thus, negotiating knowledge and action. Translation used as a metaphor in citizen science (and for the SDGs) can refer to "getting the meaning across". When communicating, either in citizen science or for the purpose of the SDGs, the question concerning the extent to which it is necessary to diverge from the original (i.e., disciplinary science and the scientific process in the case of citizen science) without distorting the meaning, may arise. On the one hand, the resulting discourse should be comprehensible to the target audience and be consistent with the target audience's rules and conventions. On the other, it should not be too free, e.g., explained in too simple terms or too far away from the original discipline and original intention.

The SDGs as well need translation, both in a literal and figurative sense. The 2030 Agenda has already been translated in several languages which is a necessary step to reach as many people as possible. Language is an accessibility issue. If people do not speak or understand the language in which the SDGs are written, the SDGs are not accessible to them.

3.2. Translation in Citizen Science

Citizen science (projects) also need translation. Providing information on a project and all related material, e.g., website, social media posts, data collection platform, app, training material, identification keys, etc. in English is not enough if citizen science projects want to reach a global audience. The assumption that English is a lingua franca and that everybody understands English, at least to a certain degree, falls short of the linguistic and cultural diversity all over the world. Moreover, using English as the only project language runs counter to the principles of inclusion, and therefore, accessibility. Linguistic barriers are also barriers and exclude persons who would be willing to contribute to a citizen science project if they understood the project material. Since there are about 7000 languages in the world, it is impossible to translate all project material in all languages. However, if local foci are defined and target groups identified, it makes sense to translate (or localize) at least the most relevant material, e.g., general information on the website, training material, executive summaries of project reports and identification keys into the local language(s) so that the target group can participate.

A study conducted for the translation industry in ten non-Anglophone countries in Asia, Europe and South America revealed that most online consumers (75%) prefer to buy products in their native language, where respondents in some countries (70% in Japan) would even buy only from websites in their local language. Additionally, people spend more time on websites in their language and 30% of the respondents never buy from websites in English [35]. Although citizen science projects and their volunteers can hardly be compared with the commercial interests of international companies and their consumers, their marketing may follow similar routes. Prospective participants who find information about a citizen science project in their language(s) may feel more appreciated or welcome. Additionally, misunderstandings due to insufficient language proficiency or false friends on both sides (the researchers' and the participants' command of English) can be minimized. Furthermore, English as a lingua franca may not only be impede communication with the participants but may have adverse linguistic consequences. If it is the only language used in academic discourse, this may lead to domain loss. This means that certain disciplines do not have a language for specific purposes, and the related terminology, in their local language. Additionally, there is an alleged drawback for non-Anglophone academics compared to native speakers, when publishing academic works [36]. This means if researchers publish citizen science project outcomes in local languages, they also foster the relevant language for

specific purposes in the local language. However, this may be detrimental to international visibility which is key in the career of academic researchers.

Language is intertwined with a person's identity. If a citizen science project intends to be dear to the heart of its participants, it should also speak the language of the participants. In particular, international citizen science projects that aim at addressing a "global" audience may need to localize contents, methods, etc. to the local circumstances, based on the understanding that English as a lingua franca might not work for everybody. This is especially apparent in biological or environmental projects, where regions differ significantly, e.g., in species and their distribution. For example, eBird (ebird.org/) asks volunteers to report their bird sightings all over the world. To help the volunteers identify birds, eBird provides so-called eBird Field Checklists. On the eBird website, users can select a field checklist according to their regions. This means only bird species that are "typical" for a region are found on this list. For example, the list for Vienna, Austria, contains 211 species, while the checklist for Shanghai, China, contains 433 species. Also, citizen science projects that are implemented in countries that have several official languages may need to translate project materials in the country's official languages. An example is the Schweiz forscht (schweiz-forscht.ch) citizen science platform that lists citizen science projects from all over Switzerland, on which projects present information in German and/or French.

This demonstrates that the significance of cultural differences is not only a major concern in translation (studies), but also increasingly acknowledged by the citizen science community, who may also adapt projects to the local context of participants (and not only to the local language).

Another example of the need for translation in citizen science is the Citizen Science Translation Hub (citscitranslate.wixsite.com/citscitranslate). Here, citizen science meets crowdsourced translation. Crowdsourcing in the field of translation, i.e., non-professional translators translating texts, is nothing new. This includes fan subbing, i.e., fans of a TV series create unofficial subtitles in their own language(s) as well as calls for crowdsourced translations by large companies, such as Facebook, which asked its users to translate the user interface of Facebook into local languages.

The criticism that is voiced against crowdsourced translation, i.e., volunteers are exploited and take away the jobs from professional translators, may remind us of the criticism that citizen science attracts too, namely the exploitation of volunteer labor, on the one hand, and the undermining of research institutions who may not need more researchers if the crowd fulfils certain tasks in the research project.

3.2.1. Translation Strategies

The translator's responsibility lies in bringing the author of the source text and the reader of the target text closer together [37]. In translation studies, two main translation strategies can be differentiated: Foreignization and domestication [38]. Although foreignization is oriented towards the source text, domestication is oriented towards the target text: "Either the translator leaves the author in peace, as much as possible, and moves the reader toward him [foreignization]. Or he leaves the reader in peace, as much as possible, and moves the author toward him [domestication]". Foreignization means the reader in the target language should not have the perception that the translation sounds like an original. Other authors follow a similar line of thought and, therefore, foreignization is also referred to as "overt translation" [39], where foreign elements of the source texts show through, "documentary translation" [40], or as a translation aimed at "formal equivalence" [41]. Other terms used for domestication are "covert translation" [39], which refers to enjoying the status of an original text in the target culture, "instrumental translation" [40] or translation aimed at "dynamic equivalence" [41]. Domestication means that the translation should read like an original [38] and be adapted to the norms and conventions of the target language.

The reason for the introduction of these two types lies in the negotiation of (cultural) differences through translation since the source author and the target readers usually have

different cultural backgrounds, which may lead to misunderstandings or misinterpretations. Therefore, by choosing one of these two strategies, translators submit to or resist dominant target culture values. Choosing the domestication strategy means to submit to the ideology of assimilation, to neglect cultural others, or to maintain canons in the target language, which is seen as imperialistic. Choosing the foreignization strategy, on the other hand, means resistance. Here autonomy, valuing cultural diversity, emphasizing cultural and linguistic differences, etc. are central [38]. Foreignization can be achieved through unconventional writing styles heavily influenced by the source text.

This ideology of following a foreignization approach was proposed for literature and creative works. However, in other domains, readers in the target language must immediately understand the content, thus the translation must "fulfil important psychological, relational, cognitive, aesthetic, social, legal or other functions in addition to the ideological ones" [42]. This means that in many areas, domestication is the desired and expected translation strategy.

However, in some cases it may be a good idea to remind the reader of the cultural difference. Here, the translator must find a balance between introducing foreignness in the target language by avoiding (unnecessary) alterations and bringing the text closer to the understanding (and reality) of the readers in the target language. However, the use of the domestication or foreignization strategy depends on the context (or the skopos) of translation. When employing domestication or foreignization strategies, it means to either observe or break with target-language conventions—or in the case of knowledge translation, to observe or break with the conventions the target audience is used to or would expect.

Knowledge translation, thus, also must find a balance between introducing foreignness, e.g., scientific terms, or domain-specific language in general, that is the key repertoire of the author, i.e., the scientists, and bringing the research (in the citizen science project) closer to the understanding and reality of the participants. Following a domestication strategy in knowledge translation would thus mean to eliminate linguistic features, such as very technical terms or scientific traits that are not in the repertoire of the participants. Nevertheless, not using scientific speak at all may also be detrimental to the participants' perception of expertise or authority of the researcher. Similar to translation, the skopos in knowledge translation can be subject to ideologies. For example, if a research project has a citizen science component just because it either makes the project more appealing to the funding bodies or it even is required in the funding scheme, citizen science may be rather a tag than an ambition. If this is the case and if citizens are rather seen as free labor force that "must" be included in research and the actual use of the research and benefits for the participants are not considered, citizen science cannot unfold its full potential, since the researchers further support existing (power) structures. Here, research articles in academic journals may be more important than achieving social change (that is required for the SDGs). Nevertheless, these projects can still contribute to the monitoring of the SDGs, e.g., by providing "traditional" data. However, since these projects may rather follow a foreignization strategy in knowledge translation, they may not reach the participants in their life worlds and, thus, would rather not be able to contribute to the further specification or the actual implementation of the SDGs as discussed above [6]. The same holds true for the translation of knowledge for policy action. If researchers do not find the right balance between foreignization and domestication, their policy briefs, reports, etc. might not be heard. Although domestication in knowledge translation may be a wise strategy in some areas, it may not be in others as this depends on the actual skopos of knowledge translation in citizen science.

3.2.2. Citizen Science as Translation (of the SDGs)

Citizen science can be conceived as translation and a means of building bridges in many ways. Citizen science can be regarded as a mediator between science and the SDGs or a mediator between the public and policymakers.

First, citizen science, which is characterized by the engagement of members of the public (who are not experts in this field) in academic research, can be considered to be translation from experts to non-experts (and vice versa). An umbrella term for this aspect can be science communication. From a functionalist translation perspective, translation is a purposeful activity that mediates between members of different cultural communities [43]. As mentioned above, the purpose (skopos) of the translation guides the translation decisions. When thinking of the skopos in citizen science and the skopos of knowledge translation in citizen science and the SDGs, it largely depends on the aim and intentions of the individual citizen science project. Additionally, the skopos reflects certain interests, ideologies, values, etc.

As mentioned above, translation is pictured as a site of tension, conflict, and negotiation but also as an enabler of change, for both the good and the worse, and for exerting or distorting power. The same does also hold true for knowledge translation and for citizen science. Translation negotiates differences, differences between languages and differences between cultures. In citizen science, this difference can be the difference between the culture of academia and the culture of participants in citizen science, the difference between the culture of policymakers and the culture of members of the public (between languages). Therefore, knowledge translation also negotiates differences, i.e., differences in knowledge as well as change and exchange. (Knowledge) translation can create impact and cause change. Although the impact of translation is often rather a positive than a negative one, there are instances when translation was, or is, deleterious [9].

Translation has been framed by various authors in terms of inherent conflict and tension. These tensions include those between source text and target text, free translation or literal translation, communicative or semantic translation, and types of equivalence. These oppositions and dichotomies have been used to classify approaches to and strategies in translation (see sections above) [44].

Translation is a means to exert or resist power structures. Therefore, translation itself is perceived as being powerful. The perceived power and impact of translation is apparent when we think about translation as a "vehicle for expressing and introducing something foreign and unwelcome" [9].

Citizen science may also be seen as forcing knowledge of the so-called Global North, a scientific worldview, and scientific methods on other people. This is especially apparent in the debate on the role of indigenous and local knowledge. This knowledge may also be considered to be valuable for the monitoring of the SDGs and as non-traditional data source for the SDG indicators.

3.3. Knowledge Translation

Therefore, the role of knowledge translation is exemplified by biocultural diversity in relation to citizen science supporting the SDGs.

3.3.1. Biocultural Diversity

Biocultural diversity refers to the "diversity of life in all its manifestations—biological, cultural, and linguistic—which are interrelated within a complex socio-ecological adaptive system" [45]. Research in this interdisciplinary and transdisciplinary field of research is subject to growing interest. Its emergence is based on the observation that these three types of diversity, i.e., biological, cultural and linguistic diversity, are threatened by extinction, and the far-reaching and devastating consequence this diversity loss ensues for the Earth and humanity. Moreover, this field postulates "an intimate link between biological, cultural, and linguistic diversity" [45]. Nature and language are inevitably intertwined, and cultures are shaped by nature. To understand a culture, we must see it in reference to its environment. The study of indigenous languages in North America in the early 20th century brought to light elaborated ways of encoding and inventorying the local landscape and its species with language. The link between the physical environment and linguistic diversity was already mentioned at this time. The researchers also described detailed

linguistic expressions in these languages for characteristics of the physical environment that may remain completely unnoticed by members of other cultures [45].

"On a global scale, the primary importance of biocultural diversity is that it is the fundamental expression of the variety upon which all life is founded" [46]. Therefore, serious concerns are voiced that the world does not only experience a loss of biodiversity but also a parallel loss of cultural and linguistic diversity [45]. If diversity in all its forms declines, the resilience to (environmental) change decreases as well. Therefore, the aim should be to preserve bio(cultural) diversity to rely on different perspectives, exploit various ways of interpretation and understanding as well as modes of interaction [47].

Knowledge is enshrined in cultural and linguistic diversity. To assess this knowledge translation is required. Moreover, biocultural diversity provides a framework for assessing the contributions of citizen science to the SDGs.

3.3.2. The SDGs and Biocultural Diversity

The 2030 Agenda states: "We pledge to foster intercultural understanding, tolerance, mutual respect and an ethic of global citizenship and shared responsibility. We acknowledge the natural and cultural diversity of the world" [1]. Translation is an important means to achieve this intercultural understanding and shared responsibility. Translation, also into lesser spoken languages, is therefore, crucial to maintain linguistic diversity. Language communities can thus access information in their local language(s) without resorting to a lingua franca or more dominant language.

Moreover, this statement explicitly refers to biocultural diversity. Although languages are an important element of the cultural diversity of the world, they are not mentioned in the 2030 Agenda. Interestingly, "language" and "translation" are only mentioned once in the entire Agenda 2030. Although "language" is used in the introduction of the Declaration as one of the dimensions referring to non-discriminatory practices to protect human rights and fundamental freedoms, "translation" is used in a figurative sense, i.e., the "translation of sustainable development policies into concrete action at the national level" [1].

The noun "technology", on the other hand, is mentioned 47 times in the Agenda 2030. The notion of "technology" can be found in ten out of the 17 goals. It is also a sub-heading under Goal 17 "Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development". This sub-heading addresses the cooperation and access to technology, innovation and science as well as the improvement of knowledge sharing (on terms that are mutually agreed). Moreover, technologies that are environmentally sound should be developed, transferred, disseminated, and diffused. Furthermore, the use of enabling technology, such as information and communications technology, should be increased and capacity-building mechanisms should be operationalized [1]. Here, technology is an important means to facilitate knowledge management and knowledge translation.

"Knowledge" is mentioned 11 times in the Agenda 2030, thereby emphasizing the development of knowledge societies. It is also mentioned as crucial for participating fully in society. Goal 2. "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" mentions "traditional knowledge", referring to biocultural diversity knowledge and other forms of knowledge except for expert (scientific) knowledge.

The Agenda 2030 contains several references to biocultural diversity: The Declaration "acknowledge[s] the natural and cultural diversity of the world" [1]. Moreover, it highlights that countries may follow different approaches and have different visions and priorities. This shows awareness for cultural (and technological) differences. Furthermore, it reaffirms "that planet Earth and its ecosystems are our common home and that "Mother Earth" is a common expression in a number of countries and regions" [1], which considers different relations between humans and nature. Moreover, it alludes to the impact humans have on ecosystems. Another section in the Agenda states that: "People who are vulnerable must be empowered. Those whose needs are reflected in the Agenda include all children, youth, persons with disabilities [...], people living with HIV/AIDS, older persons, indigenous peoples, refugees and internally displaced persons and migrants" [1]. Here (and in several

SDGs), there is a reference to indigenous peoples who play a crucial role in the biocultural diversity discourse.

Although there is a reference to biocultural diversity in the introduction to the Declaration, some authors miss Goal 18: Biocultural heritage ("Protect, promote, and engage biocultural heritage to reinforce and support sustainable interconnections between diverse human societies and their distinct environments") [48] in the SDGs themselves. Biocultural heritage is defined as the "values, cultural memory and ways of life that are tied and reflected in the places in which communities live" [48]. It represents all forms of diversity, including biogenetic, cultural memory, language, ecological knowledge, and local values as well as their interrelation. This interrelation between cultural, linguistic, and biological diversity is not reflected by the SDGs. They also do not stress the influence of culture, collective memory, and practice knowledge of the engagement with the environment. Furthermore, the SDGs do not address the loss of languages, the decline in oral tradition, the fragmentation of communities, or local ways of living. Since "biocultural conservationists argue that traditional ecological knowledge, cultural heritage and place-specific names capture a relationship and ways of relating that serves to instruct morally, perpetuating the values particular to a language and culture" [48], the relation between humans and nature is also disrupted. This link between humans and nature is especially lost if cultural traditions are disregarded or linguistic assimilation is required. For example, the citizen science project GeoKokos (geokokos.ch) can help capture the relationship between ecological knowledge, cultural heritage, and place-specified names. It asks citizens to link historical toponyms (mountains, glaciers, locations, rivers, regions, mountain shelters, valleys, lakes) retrieved from annual reports with their exact geographical location.

3.3.3. Knowledge (Co-Creation) and Sustainability

Among transdisciplinary and participatory research approaches, knowledge co-production is seen as a promising means to address current challenges, such as food security, biodiversity loss, or climate change. These challenges affect various groups of people who have different needs and interests. As these challenges are also complex and interconnected and depend on cross-scale drivers and feedback mechanisms, academic and non-academic actors identify issues and research and produce knowledge together. Co-production should help to be more effective in addressing complex sustainability issues (compared to traditional academic approaches) [49].

The four principles of knowledge co-production (for sustainability research) are pluralistic, context-based, goal-oriented, and interactive. This highlights that the knowledge process should be situated in a particular place or context and that different ways of knowing (and doing) are recognized, while clearly defining meaningful goals to tackle the relevant issue or challenge. This process is further characterized by mutual learning, active engagement, and regular interactions. The application of these principles varies according to the relevant challenge, the actors and the context [49].

To instigate change, cross-scale dynamics of social and ecological aspects and drivers, such as technology, trade, commodity prices on an international level must be considered. This requires the involvement of a wide spectrum of actors, ranging from states, supranational organizations, multinational corporations, NGOs, government and business representatives to natural resource managers [49]. To achieve change, knowledge co-production requires new forms of cooperation and direct engagement of corporate actors. An example of this can already be found for the SDG goal of marine ecosystems (keystonedialogues.earth), where business and science collaborate to achieve the SDGs. Compared to other ways of knowledge production, it can avoid or, at least mitigate, unbalanced outcomes, where there are winners and losers.

To reach the required massive and fast social change and transform society towards sustainability it is necessary to change values, cultures and worldviews, politics and power, as well as stewardship. This massive social change is required because at the moment, only superficial problems are quickly fixed, but actually the underlaying drivers must

be tackled [49]. This transformation entails the reconnection of humans to nature and restructuring institutions. Furthermore, new ways of knowledge creation for achieving the SDGs are required.

An example is "Planetary Health" that conducts research on the hierarchies and power structures related to scientists in different disciplines and policymakers regarding human, animal, and environmental health. Moreover, this can reveal the gap between global ideas and local practices and knowledge [49].

A similar example is Future Earth, which calls for knowledge integration. However, both integration and knowledge co-production require divergence from established structures in science on the organizational, cultural, and technological level. This also includes a paradigm shift from seeing sience as the active creator of knowledge and society as the passive recipient of this knowledge. Therefore, several authors call for the co-production of knowledge and transdisciplinarity [50], especially regarding sustainability. Citizen science, thus, can be a facilitator for this co-production of knowledge.

As explained in the introduction, knowledge translation can also refer to the transformation of knowledge and to the transformation of ways of knowing.

A requirement mentioned in the context of transformation of science and society is the de-institutionalization of research for autonomous action and learning [51], which entails a shift from a top-down research system heavily influenced by corporate interests to a more egalitarian view, where citizens are responsible for and have decision-making power over the production of knowledge (that includes both specialist and non-specialist knowledge) through horizontal networks. This would lead to the democratization of research, which is a cornerstone of Irwin's [52] view on citizen science. To achieve this democratization of the knowledge process, the following requirements must be met. First, there must be cultural values that are attached to the participation of citizens in setting research agendas, policies, and regulations. Second, professional values as well as participatory practices are required. Third, a learning process approach needs to be followed when generating and validating knowledge. Fourth, policies should be enabling [51]. Although citizen science fosters cultural values that emphasize the participation of citizens in academic research as well as participatory practices, the participation of citizens in policymaking regarding the SDGs and a mutual learning process approach are not of primary importance in citizen science.

3.3.4. Democratization of Science and Knowledge

Although citizen science fits well into the paradigm of democratization of science and democratization of knowledge, several authors argue for a (more) massive transformation of knowledge and for knowledge democracy. To meet the huge sustainability challenges of our times, values, assumptions, and policies need to shift. A transformation of knowledge production should result in a knowledge democracy which means that knowledge produced at mainstream research institutions, such as universities, must change and become pluralistic. This does not only require transdisciplinary knowledge but also the recognition and appreciation of multiple epistemologies (e.g., organic, land-based systems, spiritual). Therefore, authors suggest creating a link to traditional and experiential knowledge, as well as combining all dimensions, such as ecological, social, economic, cultural, and spiritual dimensions. Moreover, knowledge needs to be constructed collectively to include diverse views, interests, and values, be based on participatory action and learning, and be empowering and decentralized. Moreover, this knowledge should help finding solutions that are locally adapted and characterized by research and innovation that is shaped by citizens and for citizens. The outcomes, i.e., research and innovation as well as knowledge must be accessible [51,53].

Several of these principles are also reflected in citizen science, especially the principles of knowledge commons (e.g., open access data and publications) or participation in academic research to a varying extent. The European Citizen Science Association (ECSA) ten principles of citizen science [54] also embrace aspects of knowledge co-production such as

involving citizens in academic endeavors to acquire knowledge or understanding, mutual benefits for researchers and members of the public, non-mandatory options to participate in several stages of the research process. These principles also specify that citizens must receive feedback. However, from the point of view of co-production, citizens should be engaged in the entire research process and therefore, be involved in decision-making and disseminating information and knowledge themselves. The principles also cover mutual knowledge production and the idea to increase the visibility of the citizen scientists themselves, i.e., by acknowledging them in research publications or project results. Another aspect that clearly refers to knowledge co-production is the aspect that the experience of citizens in projects should be evaluated in addition to the broader policy and societal impact of the project. Although this means that citizen science projects do not need to orientate themselves towards societal priorities or concerns in the first place, it helps researchers to reflect on the possible impact. They may (more strongly) relate their research to broader societal concerns and reflect on the potential effects.

For knowledge democracy in academia, "new ways of knowing are needed to construct knowledge for social inclusion, economic justice, environmental sustainability and cultural diversity" [53]. This would also require a shift from setting research agendas at research institutions to a (more) participatory and bottom-up process, in which citizens do not only contribute but primarily decide on the type of knowledge that is produced, the reasons and purpose for creating this knowledge, how this knowledge is produced and for whom [53]. This also shows that the question of how knowledge is produced and by whom needs to be supplemented by the recognition of non-expert knowledge, such as experiential or traditional knowledge and self-managed research at the grassroots level. An example is the Farmer-Scientist Partnership for Development in The Philippines (MASIPAG). Here, researchers do not follow normal research practices. Instead, peasants and researchers determine research priorities together and equalize power when creating knowledge in farmers' villages and fields [55].

It has been argued that science and expertise are facing a challenge. Academics produce a wide range of knowledge, especially in the form of papers. However, it is also argued that half of this knowledge production may not stand the test of time, which means that some findings that become common sense may later prove to be wrong. For example, it "took several decades for cholesterol to be absolved and for sugar to be re-indicted as the more serious health threat" [56].

Although authors arguing for knowledge democracy prefer grassroots approaches over citizen science (because they state that citizen science are mainly projects that are designed by a small number of academics and their institutions), citizen science features a wide range of approaches, ranging from data collection projects to co-created projects, where citizens and researchers jointly define the research agenda. Although co-created citizen science projects may match the definition of knowledge democracy, knowledge co-production literature focusses on grassroots activities, such as peasant farmers, indigenous peoples or food workers who self-organize knowledge and innovation processes that they can control. Universities and research institutions are often seen as monopolies of knowledge that keep knowledge in the hands of élites and are hostile towards co-inquiry [53].

For example, grassroots communities engage in participatory research with academics on topics of agroecology, sovereignty, or biocultural diversity to transform practices, policies, and knowledge. Based on agreed roles and responsibilities, they collaborate with researchers, while also continuing to rely on pluralistic knowledge, e.g., local, tacit, experiential, or phenomenological knowledge. This is referred to as dual approach. Grassroots networks may rely on both traditional knowledge and academic knowledge and novel technologies if it meets their local needs and context. This emphasizes the incompleteness of knowledge systems [53].

Transdisciplinarity and an integrated approach to knowledge creation require the participation of academics and non-academic stakeholders in the three steps of co-design,

co-production, and co-dissemination. During the co-design step, the research agenda is set by stakeholders and decision makers framed according to the challenges related to sustainability. Associated with the definition of the research agenda are the definition of the knowledge that is required to meet the sustainability challenge at hand, including the specification of research goals, the relevant disciplines and participants and their roles. During the second step of co-production of knowledge, different disciplines and stakeholders join forces while guaranteeing scientific quality and knowledge exchange by different actors throughout the research process. The third and last step comprises the co-dissemination of the findings among the groups. "This includes publication of the acquired knowledge also in accessible language, translation of the results into comprehensible and usable information for the different stakeholders, and an open discussion on the valuation, applicability and relevance of the results among groups of conflicting interests" [50]. Since the integrated research approach includes various academic disciplines, societal groups, and regions, it should increase the understanding of multiple and interrelated drivers and interdependencies in sustainability challenges as well as create more robust knowledge and policies. Moreover, it is oriented towards concrete problems and the contexts of its application [50]. This aligns well with the knowledge-as-process approach described above since knowledge-as-process also addresses tackling challenges by applying different forms of knowledge, such as tacit knowledge in exploring or searching for explicit sources and learning from the process itself. Collaboration and mutual exchange as well as the pooling of understanding according to common goals are key.

Another important aspect that can be derived from the knowledge management literature is societal knowledge management. Since the world is constantly changing, including environments and cultures, governments have two central roles. The first role is to guide and manage change based on the underlying changing global and local conditions, capabilities, and perspectives. The second role of governments is to interpret laws and regulations according to context. This contextual interpretation necessitates, again, knowledge to meet new challenges [17]. According to societal knowledge management, public services and national plans are required to support societal development through knowledge. The society at large needs to understand the importance of knowledge for further development and application in new contexts. Knowledge building needs societal incentives as well as best practices and role models. Another prerequisite is infrastructures for knowledge generation and exchange. These infrastructures include communication technologies, education and legal mechanisms [17].

Societal knowledge management aims at building, maintaining and using a country's knowledge found in all areas of society to advance societal (and private) objectives. Relevant means of societal knowledge management are infrastructures, public education, basic research as well as information and communications technology that facilitate knowledge transfer and production [17]. This, again, aligns well with citizen science data and findings contributing to the SDG indicators. Societal knowledge management necessitates societal leadership and knowledge management to the benefit of societal goals. Moreover, to achieve these goals, priorities need to be defined. Voluntary action can guarantee effectiveness. Additionally, learning and reasoning are identified as crucial elements in societal knowledge management since all citizens "must be knowledgeable and responsible partners who can understand and judge societal issues independently to participate objectively in the public process" [17].

To sum up, citizen science can lead to the co-creation of knowledge, since it means the collaboration between different stakeholders and the academia. Furthermore, it may include co-designing the research agenda, co-producing knowledge, and co-disseminating knowledge.

3.3.5. Knowledge Management in Citizen Science

Knowledge is the main outcome of academic projects, including citizen science projects. These knowledge and data can then be used to inform the national statistical offices to contribute to the SDG indicators. Here, knowledge management is an essential aspect.

In the citizen science community, different working groups address the aspect of interoperability of data and data exchange, such as the Citizen Science Association Data & Metadata Working group or the Projects, Data, Tools, and Technology Working Group of the European Citizen Science Association, who, among others, collaborate on the development of the PPSR Core metadata standard [57]. They also work on increasing trust in data collected by means of citizen science and the re-use of data for monitoring requirements and regulations, including the SDG indicators.

Therefore, when applying knowledge translation in and through citizen science, researchers must know what, where, when, and how they communicate information to whom so that knowledge can achieve a purpose. From a translation perspective, this influences the translation strategy and the degree through which the researcher can decrease the gap between knowing and doing, between research and action, and between researchers and citizens. "For research to matter, it must be heard—and understood—by people in a position to bring about change" [58]. Citizen science that supports the SDGs should adhere to the three principles of knowledge translation: (1) Knowledge: knowledge translation needs an accessible, robust, and contextualized knowledge base. (2) Dialogue: knowledge translation depends on relationships (and trust) that can only be created and maintained through constant exchange and dialogue. (3) Capacity: all persons involved in knowledge translation need certain skills to seize knowledge translation in the best way possible [58]. This means that citizen science needs a knowledge base. Currently, many citizen science projects address the same research topic. The data of these separate projects could feed into this common knowledge base. However, the interoperability and accessibility of the data need to be guaranteed in the first place to avoid comparing apples with oranges. Citizen science is, per se, guided by dialogue between researchers and the participants, but increasingly also with policymakers to support the achievement of the SDGs. A major issue that does not only concern citizen science but the SDGs in general is capacity-building. Mutual understanding requires various skills, ranging from scientific literacy, critical thinking to communication and translation skills.

3.3.6. Citizen Science Addressing Biocultural Diversity

Citizen science can significantly contribute to the valuation and evaluation as well as the translation of implicit and tacit (biocultural) knowledge that is generally not considered in the SDG indicators.

An example to illustrate this knowledge translation is traditional agroecological knowledge systems that are considered to be a range of practices, knowledge, and beliefs about the use of an agroecosystem and its elements. This traditional agroecological knowledge is part of the world's biocultural diversity. Traditional knowledge systems are adaptive and dynamic, and, therefore of ecological, social, and economic value and essential for achieving transitions and change. However, in industrialized societies, these traditional knowledge systems hardly co-exist with other forms of knowledge systems. The reasons for this are, on the one hand, the devaluation of these systems (due to political, economic, and socio-cultural factors that impact preferences and values in a society). The modernization in agriculture led to the stigmatization of traditional agroecological knowledge systems. These are regarded to be inefficient, outdated, and unworthy. Moreover, the consumption of wild edible plants is considered a sign of poverty. Therefore, the knowledge about edible plants was imparted less and less. Another reason for the discontinuation of traditional agroecological practices in Europe is the interruption of the transmission of traditional knowledge to the next generations. This discontinuation of transmission is related to asymmetries in power relations that are based on the colonial perspective that indigenous communities are underdeveloped, and that expert knowledge must be preferred over lay knowledge. Therefore, this knowledge may be lost or the communities' ability to manage the natural resources in their region reduced [59].

A study of a citizen science program aimed at documenting traditional agroecological knowledge showed that students who conducted interviews with older genera-

tions increased the students' access to traditional agroecological knowledge, counteracted stigmatization, and led to a revaluation of the biocultural patrimony of a community, thus overcoming the devaluation of traditional agroecological knowledge systems in favor of expert knowledge systems [59]. However, only if this knowledge is put into action, i.e., agricultural practice, it can be further imparted. Putting knowledge into action is at the heart of knowledge translation.

The aforementioned study also demonstrates the relevance of knowledge transmission on different levels, such as horizontal knowledge transmission (from peers), vertical knowledge transmission (from parents) or oblique transmission (from other adults). The significance of each of these ways of transmission depends on the context and the learners themselves. In this study, the students accessed traditional agroecological knowledge by talking to older generations or researching digital sources (and less by talking to fellow students). Therefore, the author argues for "contextualized and intergenerational school activities [that] could result in both horizontal knowledge transmission through fellow students and vertical or oblique knowledge transmission through interactions with elders" [59].

This example emphasizes that knowledge alone is not enough, but that the access to a knowledge system, and especially, the valuation of a knowledge system, are crucial. The importance of valuation and appreciation of knowledge is also confirmed by the knowledge management literature. For knowledge transfer to occur in the first place, and to be successful, in the second place, the knowledge to be transferred must be of value to the recipient. Furthermore, the source must be willing to share its knowledge. Additionally, transmission channels are required, whereby a wide variety of transmission channels is beneficial to knowledge transfer. Not only the source's knowledge must have a perceived value but also the receiver must be willing to acquire the knowledge from the source. Moreover, the receiver needs the ability to acquire and assimilate the knowledge, and to use it. Finally, the knowledge must be recreated in the receiver's mind. This also means that large amounts of information are basically of little value. Only information that is cognitively processed (through learning or reflection, etc.) in a person's mind is useful. If the knowledge held by an individual or group should be useful to other persons or organizations, the knowledge must be expressed in a specific way so that the recipients can interpret it [20].

Translated to citizen science contributing to the SDGs, the knowledge management literature recommends that knowledge management (in organizations) must be monitored top-down and knowledge-related activities must be facilitated. Additionally, knowledge infrastructures need to be established and maintained. Furthermore, knowledge assets should be renewed, organized, and transformed. Finally, knowledge assets should be used or leveraged to unfold their value [22]. Within the citizen science community, organizations, or associations could assume these responsibilities. They could provide knowledge infrastructures and take care of leveraging knowledge assets to be contributed to the SDG indicators.

3.4. Holistic Approach

The SDGs aim at a more sustainable and better future. However, they are also being criticized for excluding certain perspectives and topics, such as biocultural diversity. The sheer range of topics addressed by the SDGs requires an integrated and holistic approach, including food security, nutrition, agriculture, well-being, quality of life, health, inclusion, equity, education, equality, and empowerment, water, energy, economic growth and employment, industrialization and innovation, resilient, safe, and sustainable settlements, sustainable consumption and production, combating climate change and its impact, oceans, seas and marine resources, conservation of ecosystems and reverse land degradation, and combating biodiversity loss, peaceful and inclusive societies, access to justice, effective institutions and Global Partnership for Sustainable Development.

Sustainability challenges are complex and should transcend knowledge boundaries. Therefore, research should be based on different knowledge communities, such as science, government, or business. Depending on the context, different knowledge, disciplines, and actors are needed in an open and integrated process. This also necessitates collaboration between academic and non-academic stakeholders. This collaboration should lead to a sense of ownership, accountability, and legitimacy of the solution(s). Research must change itself and focus on finding solutions (and not only on problem analysis and system understanding). This solution-oriented research must integrate norms, vision and goals to allow for intervention and transition strategies [50].

Although the SDGs require transition (or transformation), some of the goals and targets are contradictory. For example, economic growth may occur at the expense of environmental degradation. Moreover, the Agenda 2030 does hardly address the complexity and the interrelations of sustainability issues and the entire system. Related to this are also the human-nature divide. (Academic) models of ecological and landscape dynamics fall short of the "critical linkages between biodiversity, culture, spirituality and livelihoods" [51] and usually do not consider biocultural dynamics. However, the effects related to sustainability and biocultural diversity are often long-term effects. Therefore, authors call for more holistic and transdisciplinary ways of knowing. An example for this holistic approach is Indigenous Biocultural Heritage Areas that unite ecology, territory, spirituality and human well-being [51].

The SDGs, similar to many resilience indicators often rely on either humans or ecosystems. However, human well-being and sustainable ecosystems should not be considered opposing objectives and nature should not be separated from human culture. Therefore, it is necessary to see the interconnection of the well-being of humans and nature. In particular, biocultural approaches consider local knowledges and practices. They take both cultural and biological aspects and their relationships and feedback mechanisms into account grounded on the synthesis of different knowledge systems and metrics. Biocultural diversity also calls for overcoming the human-nature dichotomy by integrating diverse relations of humans to nature, considering the mutual feedback, and by defining, measuring and monitoring the well-being of humans and nature as an entire system [60].

Although the SDGs cover various areas of the ecological and cultural system, the SDG indicators are measured and monitored separately and not compared, thus taking a microscopic view. This means working within narrow disciplinary boundaries and often isolated from society. This can only result in partial solutions and incomplete knowledge. Therefore, a macroscopic view is required to find integrated solutions to major challenges. Here, all related academic disciplines and citizens should identify issues, research priorities, and research questions and, subsequently, conduct research, interpret, disseminate, and make use of findings together. Thus, research must be co-designed, co-produced, co-validated, and co-disseminated to tackle problems. It means doing science with society [53] as citizen science already does.

A holistic approach means to construct holistic knowledge, analyze humans and nature, their history and their interdependencies simultaneously across time and space, in addition to the interaction of practices on the international, national, and local levels. This transdisciplinary practice should be open-ended, participatory, iterative, flexible and overarching and include action and reflection [53]. Although citizen science is per se participatory and requires flexibility, it is often not open-ended or iterative. In particular, European funding schemes are usually targeted towards short-term research projects, which makes long-term (open-ended) and iterative actions and reflections hard to implement. These long-term collaborations and actions would also be beneficial to the contribution of citizen science to the SDG indicators.

Additionally, sustainability challenges require a unity of knowledge (also through transdisciplinary research) and a "democratic control over what knowledge is produced, for whom, how, where and with what likely effects" [53].

The ECSA's characteristics of citizen science [61] in the field of leadership and participation consider both community-led and researcher-led projects and thus also see the competence of communities and the self-determination of communities. Moreover, they acknowledge the ability of different organizations, bodies, and institutions to conduct research. Furthermore, the characteristics highlight linkages to decision-making. This means that citizen science projects can intervene in current developments, e.g., decision-making on a local level.

The ECSA's characteristics of citizen science in the field of data and knowledge acknowledge "different forms of data and knowledge generation, including novel data generation, creation of new analyses, or production of new knowledge in written and other forms". Furthermore, they also put an emphasis on open science. Moreover, knowledge sharing and application by non-academics on a local level is enshrined in citizen science since "[c]itizen involvement in producing and interpreting data gathered locally by community members, to raise local awareness and action, is a common model of citizen science" [61].

Since citizen science only addresses certain societal groups, such as middle-aged to retired educated and economically well-situated white men [62], it currently does not help to raise the voice of women, poor people, or marginalized groups, i.e., groups that are explicitly mentioned in the SDGs. Therefore, citizen science may not be able, at the moment, to meet the required transformation of knowledge and ways of knowing necessary to meet the sustainability challenge. Here, it would be crucial to "develop more autonomous and participatory ways of knowing to produce knowledge that is ecologically literate, socially just and relevant to context. The whole process should lead to the democratisation of research, diverse forms of co-inquiry based on specialist and non-specialist knowledge, an expansion of horizontal networks for autonomous learning and action, and more transparent oversight" [51].

To sum up, knowledge co-production is thus crucial to empower citizens so that they can make informed decisions and make responsible choices, thus supporting the SDGs through their behavior.

Various authors call for an integrated approach to the sustainability challenge, to providing data to the SDG indicators and to trigger social change. Although individual disciplines can contribute in several ways to the SDGs, they should work together taking into account or being guided by the priorities identified by society. However, the priority setting in research according to societal demands is also criticized as having a negative impact on academic freedom. In particular, transdisciplinary research is often characterized by research questions that are based on societal needs and by research results that support a society in making informed decisions [50].

Examples of citizen science projects that (partially) aim at a holistic approach are the Archaeological Spessart Project and the Expedition Münsterland in Germany.

3.4.1. Archaeological Spessart Project

The Archaeological Spessart Project addresses the cultural history of the Spessart region in Germany from the very first human traces to the present times. As a cooperation project between different universities and research institutions, it covers issues from a wide range of disciplines, including history, language, culture, landscape development, geography, geology, or biology. It intends to shed light on environmental and climate change, the mutual influence of humans and nature and cultural landscapes shaped by humans over thousands of years [63]. The methods applied are as diverse as the topics themselves, ranging from geophysical measurements, pollen analysis, dendrochronology, archaeological prospections and excavations, analysis of archival material, aerial pictures to the mapping of indicator plants and vegetation characteristics. This way, the researchers aim at reconstructing the history of the cultural landscape in the Spessart region. The data that are collected by volunteers feed into a geographical information system that gives a comprehensive picture of the region also beyond provincial borders [64].

This project demonstrates that understanding human-nature relations and the mutual influence between humans and nature require a holistic approach that includes a wide range of disciplines and combines multiple methods to acquire comprehensive knowledge of a region. It also shows that involving citizens from the very beginning in academic research is important to achieve buy-in and ownership of the project (and the region). Moreover, it highlights the significance of knowledge translation: the translation between different disciplines (domain-specific language, including terminology), the translation of research into practice, and the translation of both academic knowledge and the academic research process into generally comprehensible material and processes.

3.4.2. Expedition Münsterland

The Expedition Münsterland project is another example of the holistic approach to citizen science and the co-production of knowledge. The citizens can contribute to the collection and compilation of information and the dissemination of the acquired knowledge through events.

The project addresses unique sites in the Münsterland region in Germany by making university research visible in the region. By creating a bridge between science and society, it enables exchange between the local university and the inhabitants of the region, including citizens, communities, and corporations. As it strongly depends on the contributions of volunteers, citizens can propose sites of interest or initiate events. They can also contribute significantly to the organization and contents of joint research events. Together with citizen initiatives, regional associations, and organizations, the university researchers collect and compile information on the relevant sites according to academic principles. The diverse knowledge of the sites and their history are presented during local events. The events facilitate citizen science dialogue and knowledge exchange [65].

This shows that citizen science "has untapped potential to build capacity for transformative research on coupled human and natural systems" [66]. By integrating a coupled system approach, which is crucial to understand the critical interactions between nature and humans and their influence on ecosystems over time, citizen science could collect paired social and ecological data from the same person to support large-scale (longitudinal, spatially diverse) studies on coupled human and natural systems [66].

3.5. Usability and Accessibility

The frequency of the term "technology" used in the Agenda 2030 highlights the role of technical applications and devices for sustainable development. This shows the relevance of usability and accessibility of these technologies. For example, in citizen science, most of the projects require their participants to use technology, either in the form of an app, with which they collect or analyze data, such as sightings of flora and fauna or a web interface via which they can enter or analyze data. Technology is not only widely used in citizen science initiatives, but also a major means of knowledge translation. In this context, usability can be seen as a form of translation that requires the translation of design into the users' expectations towards an intuitive use of technology. This is exemplified with the SPOTTERON platform.

The SPOTTERON platform (spotteron.net) currently features 26 national and international citizen science projects in a wide range of disciplines. Most of the projects on the platform can be allocated to the natural sciences. Additionally, projects from the social sciences, cultural studies, and arts are run via the platform. Since this platform also features global citizen science projects, it also allows for localization, i.e., the adaptation to the local context. Since the global projects are based in the United Kingdom, Suriname, Sweden, Germany, Australia, and Austria, the individual apps must be available in different languages.

The SPOTTERON platform has a focus on the users, i.e., citizen scientists and their requirements. Therefore, the look and feel of the apps on the platform, the user experience, and thus, the usability for novice and experienced users alike are aimed at the long-term

engagement of users (in a citizen science activity on the platform). Therefore, the sense of contributing to something big(ger), emotional engagement, and long-term motivation should be triggered by social features, such as liking, commenting, or news feeds that may increase the sense of community within the tool. Although the individual projects have individual apps on the platform, all features and the interactive map application that allows for georeferencing of data are available to all projects. This modular system guarantees that all apps share the same basic system, but the functionalities are customized for each project. Moreover, projects can re-use the features that are already available [67].

The example of SPOTTERON should illustrate a way of consolidating knowledge within a platform and the multilingual aspect of translation in citizen science. In particular, the integration of knowledge from a diverse range of disciplines would allow a holistic view on sustainability challenges and biocultural diversity and thus, on ways of achieving the SDGs. For example, since all the data are stored in a uniform way, data interoperability is higher. Furthermore, data from different citizen science projects could easily be combined, e.g., combining data from the Naturkalender app, on which citizens collect phenology data, with mycological data from the Pilzfinder app or bird data from the Waldrapp app in Austria. This may allow conclusions to be drawn across species and help to be offered finding interdependencies or correlations. In addition to getting a bigger picture of a certain region and its environmental conditions, also comparisons across countries would be possible. Furthermore, data from different fields of science, such as data from natural sciences, social sciences, and the humanities could be used for integrated research. This may provide a holistic view on the aspect of biocultural diversity.

4. Conclusions

Knowledge is generated and circulated in organizations, networks, or communities. To have an effect beyond an organization, a community or (citizen science) project, this knowledge needs to be translated (in the broad and narrow sense).

Technology and language are means of knowledge translation. On the one hand, knowledge is embedded in technology and language themselves. On the other hand, culture and language are ways of perceiving and interpreting the world. They reveal values, purpose, and human–nature relations. However, knowledge alone does not suffice to achieve societal transformation to achieve the SDGs. Values, assumptions, and perceptions need to change. Here, knowledge co-production and knowledge translation play a crucial role. The recognition and consideration of pluralistic knowledge, the combination of these different types of knowledge (expert, tacit, traditional, local or experiential knowledge) as well as global and local knowledge can contribute to the societal transformation intended by the SDGs. Moreover, knowledge democracy and the democratization of science rely on participation, which is also at the heart of citizen science. Citizen science still has a way to go in reflecting diverse interests and values, and in finding locally adapted (practical) solutions. Moreover, it may increase decision-making power and the responsibility of the participants. In particular, transdisciplinary and holistic approaches that link different disciplines from all fields of science with different types of knowledge contribute to tackling the sustainability challenge. Knowledge translation, furthermore, reminds us that knowledge and science are socially constructed. Knowledge often reflects and supports power relations and worldviews. To achieve deep systemic change, also new knowledge paradigms and ways of knowledge translation may have to emerge.

To ensure that citizen science supports the SDGs, researchers need to speak their participants' language. Reaching the SDGs is only possible if the SDGs can be connected to people's (everyday) life worlds. Therefore, citizen science can be considered an entry point to the SDG framework, as a gate to knowledge, as a gateway to academia and as a framework for sustainable knowledge translation (in all directions). Knowledge translation thus provides the link between knowledge and practice.

When viewing citizen science from the translation perspective, it has several commonalities with translation in general, and knowledge translation, in particular. Moreover, citizen science also touches upon aspects of usability and accessibility.

Classical translation from one language into another language can foster accessibility, since it helps to lower linguistic barriers in citizen science. Although English is considered a lingua franca, providing material in a citizen science project or on the SDGs only in English already excludes a wide range of people.

Knowledge translation does not happen in a vacuum but is embedded in a broader socio-cultural context. For knowledge translation to be successful, the process of knowledge translation and the final products need to be made explicit and undergo quality assurance. Knowledge translation means to provide sufficient information that makes sense and is meaningful to the receivers. Nevertheless, it is important to consider and be aware of barriers to knowledge translation.

"Translation" in citizen science carries various meanings, ranging from science communication or localization to address a certain community and/or region appropriately, to translation of research (or the SDGs) into values or into action.

Regarding technology, but not limited to technology, translation can also refer to the translation of the user needs and expectations into product, system or project design as well as the translation of citizen science outcomes into meaningful results for the participants. Additionally, translation can also refer to touch a nerve of society or policy. Moreover, it can address the translation of research into local tangible ideas or actions required for societal transformation. Translation in citizen science can additionally refer to the translation of scientific knowledge into comprehensible language and easy terms, or translation from academic discourse into public discourse, or translation from academic discourse into policy areas.

This demonstrates that translation at the interface between citizen science and the SDGs can carry manifold associations and connotations, ranging from the translation of research into action or the translation of abstract goals and indicators into concrete and transparent steps and measures. To conclude, citizen science guided by or supporting the SDGs requires different forms of knowledge ((and) translation) that are usable, accessible, and meaningful.

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