

## Article

# Exploring Citizens' Adoption of Sustainable Innovations Implemented by Cities and Municipalities in Germany

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**Abstract:** Sustainable innovations, such as sustainable products or services, are becoming increasingly relevant for society and thrive on societies' knowledge and usage. But this is where many cities/municipalities are experiencing disharmony: citizens often do not know that these sustainable innovations exist and, therefore, do not use them. Our study starts at this point: To address this disharmony in Germany, the government has established the German Sustainability Award, which honors cities/municipalities with outstanding sustainable innovations. We qualitatively surveyed the citizens and administrations of these cities about their knowledge and use in their city/municipality (using eight categories) under the theoretical lens of Rogers' (1960/2003) Diffusion of Innovation Theory (DOI). In 29 interviews in six cities/municipalities, we were able to match sustainable innovations based on DOI. In particular, we determined that few sustainable innovations were only found in specific categories (such as economy (EC)), while others existed in all (such as climate and environment (CE) or education (ED)), and, e.g., city/municipality's size did not matter at all.

**Keywords:** diffusion of innovation theory (DOI); innovations; municipalities; sustainable development goals (SDG); citizens view



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## 1. Introduction

A growing number of cities and municipalities are developing sustainability strategies to make all municipal and urban processes and services sustainable [1]. On the one hand, this is performed to fulfill the 17 sustainable development goals (SDG) of the United Nations (UN) [2] and, therefore, also the follow-up strategies of the European countries. In Germany, the German sustainability strategy was developed in 2016, which was adapted and expanded in 2021 [3]. Furthermore, the European Green City Award is given for the greening of public spaces through innovative ideas based on scientific research and technical expertise and is awarded in 13 countries [4]. Another sustainability award is the Guangzhou International Award for Urban Innovation, which aims to recognize innovations that improve the social, economic, and environmental sustainability of cities and regions in order to promote the prosperity and quality of citizens' lives [5]. On the other hand, the available municipal resources (in the form of working time, financial investment, and opportunities) must be used consciously and intelligently to ensure that the transformation to a smart city is successful [6]. In doing so, Caragliu et al. (2011) describe a city as "smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" [7]. In this context, "sustainability is [...] defined as utilizing resources to meet the needs of the present without compromising the ability of future generations to meet their own needs" [1]. In Germany, however, the topic of "sustainability" has been pursued for a long time. Since 2007, the German Sustainability Award (GSA)

Foundation has awarded the prize in various categories (e.g., design, architecture, or start-ups) [8]. Since 2012, it has also been awarded to cities and municipalities of all sizes in three categories ((1) major cities, (2) medium-sized cities, (3) small towns and municipalities) that have implemented particularly impressive projects. In the year 2022, the prize will not be awarded, but the requirements will be revised to coincide with the 10th anniversary [8]. Nevertheless, it is apparent that the GSA and sustainability are relevant topics in the private sector, where many studies have been conducted (e.g., [9–11]) and reports produced (e.g., [12]). Drivers and challenges are analyzed, and solutions are developed. In the public sector, in contrast, there is currently a lack of scientific knowledge on how sustainability is implemented. It is to be highlighted that sustainable and innovative projects of cities and municipalities for their citizens do not reach the citizens' knowledge despite careful preparation, implementation, and communication [13]. This does not only lead to the anticipated improvements in the long term but also, in the worst case, to possible serious disadvantages, such as high running costs without ongoing revenues or the renunciation of investing in sustainable and innovative projects in the future. Therefore, it is of high importance that citizens have knowledge about local sustainable innovations initiated by their cities and municipalities.

From a green information systems (IS) perspective, there is currently a lack of meaningful studies that examine the process of innovation adaptation in relation to sustainable innovations in more detail [14–16]. We understand innovations as “[. . .] the multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace” [17], which are implemented with information- and communication technology (ICT).

The objective of this study is to investigate how the implemented sustainable and innovative projects of cities and municipalities that have won the GSA are known and confirmed by the citizens. In other words, what is the adoption process? The theoretical basis of this study is the Diffusion of Innovation Theory (DOI) by Rogers (1960) [18]. The DOI shows the adoption process through five stages (from knowledge to confirmation) in a social system. Building on our previous research [19], in this follow-up study, we want to find out to which degree citizens are knowledgeable of sustainable innovation initiated by their cities or municipalities.

**(RQ):** To what extent do citizens know and confirm sustainable innovations of their cities and municipalities?

This research looks at both the citizens' and administrative perspectives to fully analyze which DOI stage citizens are at and what actions municipalities are taking to ensure that citizens move through all stages. The dual perspective of citizens and administrative members provides deeper insights; thus, an approach was developed to address the unique environment of the public sector.

## 2. Theoretical Background

### 2.1. Sustainable Innovations

Sustainability has become an omnipresent topic in recent years [20,21]. Since the UN created the 17 SDGs in 2015, governments, cities, companies, individuals, and many more are attempting to meet them by 2030. Companies are trying to make their processes and products progressively more sustainable and efficient; there are, for example, energy labels for products on a scale from A to G, which indicate how energetically good or bad the product is (energy consumption, water consumption, noise, etc., are included in the calculation), or digital processes are introduced to reduce the amount of paper and eliminate redundancies, or sustainable innovations are launched to be prepared for future crises [22,23]. The three pillars of sustainability (economic, social, and environmental) should always be addressed [24]. Sustainable and innovative projects are understood as sustainable innovations in the context of this study because, following the definition of Baregheh (2009), firstly, innovations are broad and include products, services, or processes. Secondly, we

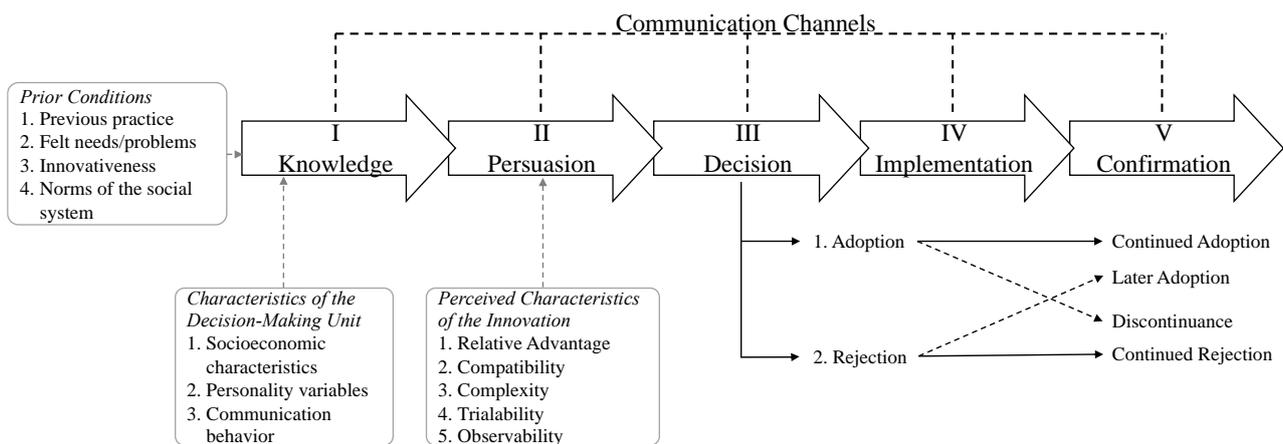
consider only sustainable innovations in the context of this study, e.g., innovations that can be used by cities and municipalities to achieve the 17 SDGs. Thirdly, we consider sustainable innovations that are predominantly ICT-based [17].

Cities and municipalities try to achieve the SDGs by modernizing their processes or establishing sustainable innovations [1]. In many cities and municipalities, these activities are bundled into sustainable strategies. However, it is noticeable that the citizens of cities and municipalities often lack knowledge about these sustainable innovations, and utilization does not become the norm (as shown, for example, by the study of [25]). In order to give decent recognition to the sustainable innovations of cities and municipalities, the government in Germany established the GSA for cities and municipalities in 2012 [8]. This is awarded in three categories ((1) major cities, (2) medium-sized cities, (3) small towns and municipalities). The range of sustainable and innovative projects honored is very broad, e.g., climate protection, animal welfare, education, migration, resources, or health. When a city or municipality wins the award, it shows that the administration is actively addressing the issue of sustainability. However, the question arises whether these efforts also reach the citizens and if there is enough knowledge in the city or municipality about the sustainable innovations that these are also tested, used, and adapted in the long term. With the help of the DOI, this question can be investigated.

## 2.2. Diffusion of Innovation Theory

The Diffusion of Innovation Theory (DOI) by Rogers (1960) has long been a proven tool to measure the success of (mainly technological) innovations. Success, in turn, can be used to draw conclusions about the adoption process [18]. Rogers (2003) defines “an innovation [as] an idea, practice, or project that is perceived as new by an individual or other unit of adoption” [26] (p. 12). The DOI thus represents a combined theory of success measurement and illustration of the adoption process and “focuses on understanding how, why, and at what rate innovative ideas and technologies spread in a social system” [27]. In the field of IS, the DOI has also often been used for technological innovations, as in the case of (e.g., [28,29]), as well as in other areas, such as agriculture, science, or technology [30].

The DOI describes an innovation-decision process, and Rogers (2003) explains this process as a “process through which an individual (or other decision-making unit) passes from gaining initial knowledge of an innovation, to forming an attitude towards the innovation, to making a decision to adopt or reject, to implementation of the new idea, and to conformation of this decision.” [26] (p. 168). Based on this definition, the five stages of DOI become clear: (1) Knowledge, (2) Persuasion, (3) Decision, (4) Implementation, and (5) Confirmation (see Figure 1). The innovation-decision process starts with the Knowledge stage (1). Knowledge is created when a person learns about the innovation and gets to know the background and functionalities. Then follows the Persuasion stage (2). From this stage on, the five characteristics of an innovation take effect, which we describe in more detail in the next paragraph. Persuasion starts when a person develops a positive or negative attitude towards the innovation. However, this initial attitude does not lead to adoption or rejection in the same direction. In the middle of the process is the Decision phase (3). Here, a person decides whether to adopt or reject the innovation. Rogers (2003) further describes the process after adoption/rejection, namely that either continuous adoption/rejection occurs or a mixed form (later adoption after rejection or discontinuance after adoption). The decision is followed by using the innovation, e.g., the Implementation stage (4). In this stage, the main problem is uncertainty about the innovation and its expectations, which should be overcome within the stage. The last and final stage is the Confirmation stage (5). It is about living the decision made without being distracted by arguments that are against the personal decision. However, if these arguments distract one personally too much, it may come to a change, e.g., to discontinuance [26].



**Figure 1.** Five Stages of the Diffusion of Innovation Theory (DOI), adapted from Rogers [26].

From the Persuasion stage on, the five characteristics influence the innovation-decision process. (1) The relative advantage describes the degree to which an innovation is seen as more beneficial than a (following) alternative. (2) Compatibility describes the degree to which an innovation can be superimposed by existing values, previously lived experiences, and the new peoples' needs. (3) Complexity describes the degree of difficulty in understanding and using the innovation. (4) Trialability describes the degree to which an innovation can be tested before it is actually used and adopted. (5) Observability describes the results' visibility degree of new innovations to other people [26].

Using DOI's innovation-decision process, this follow-up study will identify the stage of awarded cities and municipalities for individual sustainable innovations. In the field of sustainability, it is becoming increasingly apparent that sustainable innovations are rarely or not at all perceived by citizens. For this purpose, we want to take a closer look at the stages that citizens go through in terms of sustainable innovations.

### 3. Method

#### 3.1. Method Selection

Building on our previous research and following our research agenda [19], we use a qualitative approach [31] for the follow-up study to investigate the activities that explain the status of DOI's stages [26]. We took a deductive approach by considering both citizens' and administrative employees' perspectives in the interviews to draw our findings. In this way, we aim to take a dual perspective of the adoption process and contrast the activities of cities and municipalities with the impressions of citizens. We selected the cities and municipalities iteratively and theory-driven, as described earlier in our research agenda [19]. We used a random number generator to select two winning cities and municipalities per category (major cities, medium-sized cities, small towns, and municipalities). In the following, the cities and municipalities are numbered according to their size: major cities with L, medium-sized cities with M, and small towns and municipalities with S. In addition, the administrations are marked with an A. We asked the administrations of the cities and municipalities for interviews in the first step. If we received refusals, we selected a new city or municipality with the random generator in the second step (sampling without replacement). In this way, each city and municipality had the same chance to be selected at any time. In the third step, we conducted a follow-up study among the citizens of the selected cities and municipalities. We asked all interviewees about the activities in the eight categories we identified in previous research [19] according to Mayring and Fenzl (2014) [32]: content analysis (climate and environment (CE); nature and animal welfare (NA); government (GO); education (ED); economy (EC); migration (MI); resources (RE); health (HE)). For a broader range of responses, we allowed participants to speak freely and used a semi-structured guide with open-ended questions [33]. We followed Sarker's guidelines for

qualitative research to avoid the pitfalls of qualitative semi-structured interviews [31,33]. To test the first version of the questionnaire, we conducted two preliminary interviews. Afterward, we slightly adapted and improved the questionnaire to achieve the best possible findings with bottom-up coding. We did this for both the administration and the citizen questionnaire.

### 3.2. Data Collection and Analysis

In our follow-up study, we conducted 29 virtual interviews with an average length of 60 min. We conducted the interviews from September 2021 to March 2022 in Germany. Among the 29 interviewees were 7 administrative employees and 22 citizens, as well as 14 men and 15 women. The interviewees were between 22 and 73 years old, on average 39.3 years old, and living between 1 to 73 years in their city or municipality. The average lifespan of the citizens in the city or municipality is 23.8 years, and that of the administrative employees is 32.6 years.

The citizen questionnaire is divided into five parts. The first part contains the demographic information of the interviewee (e.g., age, lifespan in the city or municipality, job, ICT competence). The second part deals with sustainability, how the interviewee feels about it, and why sustainability (in their city or municipality) is important to them. For example, "What does sustainability mean to you?" or "How do you inform yourself about sustainable innovations in your city or municipality?" In the third part, we queried the five stages of the DOI on known sustainable innovations in the city or municipality, such as, "How did you find out about the sustainable innovation?" or "Have you tested the sustainable innovation in the past and if so, what was your experience?" We also asked about the five characteristics, such as, "How would you describe the compatibility of the sustainable innovation with other municipal innovations?" In the fourth part, we talked about the unknown sustainable innovations and elicited causes for the lack of knowledge, as well as whether the interviewees would like to deal with some of the addressed sustainable innovations with questions such as, "What could be causes for the fact that you do not know about these sustainable innovations?" Finally, the fifth and last part is about communication with the city or municipality and information gathering about sustainable innovations. Sample questions here are: "How did you find out about sustainable innovations?" or "What could your city or municipality do better that more citizens know about and use the sustainable innovations or planned ones?"

The administrative questionnaire is divided into four parts. The first part is identical to the citizens' questionnaire. The second part is also about sustainability. Additionally, it discusses how the citizens are informed about sustainable innovations ("How informed do you see your citizens about what is happening in your municipality?"), why the municipality participated in the German Sustainability Award, and what meaning and impact the win has. The third part is identical to the citizen questionnaire, and the fourth part is about citizen participation, such as "Have you involved your citizens in the sustainable innovations process? And how?"

The interviews were recorded in German, transcribed non-verbally, and translated into English for analysis of the activities. Afterward, the interviews were analyzed and subdivided according to the eight categories using the MAXQDA 2022 software. Among the authors, we independently coded the interviews and noted the status of each stage for each activity. In addition, we looked for the motivations for changing or not changing stages. Halfway through the interviews, we discussed and grouped the results within the author team, resulting in an inductive loop following axial coding [34]. After agreeing, we revisited the first half and analyzed the other half. If different opinions arose during coding, these were discussed among the authors' team and resolved by consensus. For example, in the following quote, "Sustainability is important to me because I would like my descendants, especially my daughter, to be well off in the world for a long time to come and not have to think so much about how long the world will continue to be good, but I am convinced that everyone has to do their part. And we now have to work extremely hard to

ensure that we are on the road sustainably." For (L1-4), two independent codes ("Impact" and "Generation") were found. Finally, "Impact on next generations" was used as the axial code. We ended the analysis at saturation, e.g., when no new motivations for the status of the stages or their transition were found.

#### 4. Findings

In the following, we would like to show the findings based on the DOI and highlight special characteristics. For this purpose, we will successively follow the stages and characteristics of the DOI based on Figure 1.

##### 4.1. Knowledge

Most interviewees know about GSA projects indirectly by sight. While walking through the city or neighborhood, the interviewees noticed new projects, stores, or changed urban elements that have been implemented by the administration. This is reinforced by advertising in the form of posters or signs. The second most common way interviewees knew about GSA projects was from their work environment, but less so from friends or family. The third most common way interviewees took their knowledge of sustainable innovations were from the newspaper (analog medium). Here, daily newspapers were mentioned, but also regional newspapers and especially the free and municipal newspapers (mostly on weekends). In addition, knowledge about the projects was drawn from events and from social media, or in many cases, supplemented by them.

*"We just went for a walk, walked around the neighborhood here and saw the [store] and thought we'd give it a try." (L2-3)*

*"So [the project] is really striking, so you have to be blind not to see those." (L1-5)*

*"I think about the newspaper. So, everything that's in [name of city], of course you find out about it through the regional newspaper, that's how it is." (M2-1)*

Citizens were familiar with the sustainable innovations from the categories CE, NA, and EC mainly by seeing them. Sustainable innovations from GO are known mainly through social media and the newspaper by citizens. Sustainable innovations from ED are recognized by citizens through seeing and hearsay, as well as through events. Sustainable innovation from RE was mainly known by citizens their work environment. For the administration in particular, it shows that its efforts are visible and are recognized and seen by its citizens, but it is clear that the administration needs to be much more intensive and active.

##### 4.2. Persuasion

The next stage describes the extent to which the citizens have informed themselves about sustainable innovations in order to form a positive or negative opinion as well as to acquire knowledge about the five characteristics that influence the innovation-decision process. It was found that citizens in the categories CE, GO, EC, and MI mostly went further to inform themselves about sustainable innovations. In the categories ED and RE, this was mostly not the case; here, the interviewees did not inform themselves further. From the administrative perspective, it is crucial that citizens independently approach the administration and obtain information on changes or innovations. The administration has access to citizens, but there is usually a lack of knowledge on both sides, administration, and citizens, on how they can build up or share the missing knowledge with each other.

###### 4.2.1. Relative Advantage

Because of the diversity of sustainable innovations, the relative advantages are equally diverse. We want to show the relative advantages based on the categories.

In the category CE, several relative advantages of sustainable innovations are mentioned. There are measures to strengthen climate protection (through climate protection concepts), establish more renewable energy sources, promote autarky, improve wastewater

treatment systems through high-tech wastewater treatment plants, or improve mobility through ICT applications. Here, the advantages of traffic flow optimization, alternative means of transport, traffic calming, accessibility, or the expansion and promotion of electric mobility are mentioned, which have been implemented by the administration.

*“That’s why it’s a great stroke of luck to have wastewater treatment plants in urban areas where you can use all three of those things.” (L2-3)*

*“The advantages are that it is much more efficient, you save a million tons of CO<sub>2</sub> per year. You can provide energy much more effectively when there is a demand for energy or not, you can intervene in the power grid much faster and more effectively than with a coal-fired power plant. The pollutant emissions are accordingly also significantly lower than with a coal-fired power plant.” (L1-1)*

In the NA category, the relative advantages of nature conservation, e.g., green bus stops or sustainability experience paths, the strengthening of biodiversity through flowering meadows and parks, or waste reduction, are mentioned, and this shows that the efforts of the administration are recognized.

*“This is along the local heating pipeline and just exemplary at several stations are topics such as energy consumption, energy saving, where does the energy come from anyway? How does a local heating network work? [explained]. There is also a residential house, where it is exemplarily shown, how a thermal insulation affects the energy consumption. Economy shower heads in the sports halls. That’s really good.” (M1-3)*

*“Well, I think it’s good. I mean flowers are beautiful, everyone is happy about it. I also think it’s good, especially that the plants are pollinated and so on. And that the ecosystem then remains intact. Therefore, of course, this is to be welcomed.” (L2-1)*

In the GO category, interviewees name, as relative advantages, that they are actively involved through citizen dialogs or participatory processes. In pandemic times, this was given a virtual space. The administration is making great efforts to ensure that they involve their citizens in processes and decisions as far as the law allows, and the results show that these efforts are very well received by their citizens to work together in the future.

*“It didn’t seem as if there was any intention behind it, any party that wanted to have its program confirmed, but rather very open. As if they were really interested in the results. Whether they will be implemented is, of course, another question. There were also many questions about mobility, which pleased me. And also, about the redesign of streets, the reuse of public spaces—from streets to public squares—removing parking strips and planting trees and park benches instead or from car lanes to bike lanes. That was a big focus.” (L2-3)*

*“Well, simply that you are brought on board, that you can contribute, that you learn something at the same time, but also that you can influence a certain—yes, perhaps also that you have the feeling that you are also taken seriously and can share your opinion, so to speak.” (M1-2)*

In the ED category, interviewees see many relative advantages for the current shortage of skilled workers and passing on knowledge to the next generations. Through sustainable innovations in the field of ED, new specialists can be recruited, perspectives for young people (especially in socially disadvantaged cities and municipalities) are created, digitized training is offered, the next generation is promoted, and schools and daycare centers are integrated holistically, e.g., through extracurricular educational venues. To counteract the lack of qualified workers, the administration is dependent on cooperation with its citizens. In particular, many creative and unusual new educational opportunities are having a positive impact.

*“So, we have the whole range of what STEM only covers and we have a shortage of skilled workers now already clearly visible, and the [sustainable innovation] helps there.” (M2-4)*

*“Very positive, because it ensures that students or people in general get to grips with the subject by actively discovering things. I see this as a great advantage, actively discovering things.” (M1-1)*

In the EC category, there are many relative advantages, both on the business side, such as a strengthening of tourism, cooperation between business and science, or the settlement of start-ups that distribute, develop, or similar sustainable innovations. On the other hand, there are also benefits for citizens, such as the promotion of photovoltaic systems or the possibility of acquiring shares in citizen cooperatives for sustainable innovations. In the context of EC, it was also mentioned several times that sustainable innovations create more affordable housing, and this fosters sustainable cohesion between administration and citizens.

*“Other tangible advantages in the area that of course all the activities in total got me thinking for myself. And I have also looked at our own house, which is now also with solar thermal from the beginning for one and a half years with a small photovoltaic system and an energy storage and anyway always with a green electricity tariff quite well, I think, which affects the CO2 balance. And currently the advantage is that rising oil and gas prices and partly also rising electricity prices do not affect me. A very tangible advantage. All through the funding’s.” (M1-3)*

*“So, advantages are of course clear on the one hand, there are many jobs. I think 400 jobs are to be created there. And I think that’s a good possibility.” (M1-4)*

In the MI category, interviewees indicate that sustainable innovations have reduced prejudices, strengthened inclusion and integration, and enabled cultures to get to know each other better. The strengthening of togetherness is thereby promoted and shows that the administration must increase its efforts in this field in order to keep anchoring harmonious togetherness in society.

*“I already had the feeling that the information about [migration project] and the discussion that arose from it, also on Facebook or in the circles of acquaintances, led to more information being held. Many prejudices could be reduced. [...] That one has informed there actively and has invited the people, one could ask questions. [...] You become more multicultural and that also has its advantages. They also bring many interesting things with them, the other cultures. That’s why I believe that it’s important to deal with this openly and to actively promote it [...].” (S2-1)*

*“It was also about shaping migration from a different perspective with people who have a migration background at eye level, living together.” (L2-1)*

In the RE category, basic, as well as innovation-specific relative advantages, emerged. Among the basic relative advantages, it was mentioned that sustainable innovations can save resources, fair trade becomes more established, and volatility can be reduced. The experts among the interviewees also pointed out very specific relative advantages, such as the triple use of the products in gas-fired power plants that are connected to the district heating network and where the by-product hydrogen is also used. This increases the efficiency of the systems enormously.

*“So, I do think that this would save quite a lot of resources.” (S2-3)*

*“We have developed a tool where you specify the building components, right down to the building material itself, and this tool then automatically calculates the corresponding resource savings, greenhouse gas savings and energy savings compared to a conventional construction method. In other words, we have developed a benchmark for comparison of how conventional construction is done today and how it is possible to construct buildings in such a way that they use at least 50% fewer resources, produce fewer greenhouse gas emissions, and consume less energy.” (S2-A)*

In the *HE* category, the interviewees stated that sustainable innovations have digitally strengthened fitness, even in pandemic times. It was mentioned that digital was not a problem due to the targeted promotion of seniors.

*“But for me, it was also the starting signal for a whole series of projects in this direction. I think it was one of the first projects to deal with the topic of digitization, health, assistance systems in old age, and how digitization can help the elderly population. I think it was—at least in my opinion—one of the first projects that really became well known. Not least because of such a sense floor, because it was simply funny to walk across such a sensor floor and it was also played out nationwide via certain reports. And for me, that’s a process that has absolutely set impulses.” (S1-A)*

Relative advantages were not only evident in the eight categories but also in those that cannot be directly assigned to these categories. However, these can be summarized in two points. First, there are the classic attributes of a Smart City, and second, there are the characteristics of sustainable innovations.

The interviewees formulated the attributes of the Smart City as follows: they consider it advantageous that the attractiveness of the city or municipality is strengthened by sustainable innovations, that the quality of life in the city or municipality increases, that the future is actively reshaped, that the structural change is met and that the citizens of a city or municipality are enabled to become Smart People through exchange, further education, places of encounter, and offers of help. The administration benefits from this because citizens recognize their work as valuable and beneficial. This shows that citizens feel comfortable and trust in their administration.

*“I think it definitely has an attractiveness character and that sense of unity is strengthened. That again the downtown is perceived as a downtown.” (S2-1)*

*“Mega as I find it just generally down there in [name of city], it just become so much livelier in recent years, that’s totally cool.” (L1-5)*

*“To make the [city] more attractive.” (S2-3)*

*“According to the motto, in a healthy body also lives a healthy mind.” (M2-2)*

The relative advantages of sustainable innovations lie in their characteristics. The interviewees describe that they are more flexible, have less stress, save time, are more efficient, have more fun, feel safer, and have a low financial investment.

*“This has a clear financial advantage for me and my family.” (M1-3)*

*“So, the event is just fun.” (L2-4)*

*“It looks like here is fun, here is sport and here is joy for everyone and not only for the wealthy people of this city.” (L1-5)*

#### 4.2.2. Compatibility

Compatibility is perceived differently by interviewees, with the vast majority agreeing that sustainable innovations have been or will be well integrated into the cityscape. Accordingly, the work of the administration is seen as valuable and highly appreciated. For example, major cities mentioned bicycle networks that connect all points in the city without interruption and can be viewed via diverse (digital) applications, or smaller towns and municipalities mentioned educational opportunities with digital components that can be experienced both in the city/municipality and from home, and for both pupils and seniors.

*“Not over the top.” (L2-3)*

*“At least my impression is that it hasn’t made the cityscape worse because [name of city] is not an old city.” (S2-2)*

*“I think that the [name of sustainable innovation] has just been perfectly integrated into the city. By really choosing the prominent places where most people want to go too. And*

*from any main streets or main buildings, there are also and off-ramps to the [name of sustainable innovation]. The city has initiated a very good project.” (L1-4)*

*“I would say that is actually pretty well solved, because the bioenergy park just for example also accommodates the landfill and now also a research site is incorporated. So, it all fits together pretty well.” (M1-2)*

The sustainable innovations from categories *NA*, *GO*, and *ED* were all described as highly compatible. In the *CE* and *RE* categories, the interviewees felt that sustainable innovations were medium to highly compatible. Only in the *EC* category was one sustainable innovation described as low compatible, with no opinion expressed about the other sustainable innovations. Therefore, we do not weigh this too heavily.

#### 4.2.3. Complexity

In many cases, the complexity could not be adequately assessed by the interviewees, but among the interviewees were also some experts who had much knowledge about some sustainable innovations from the professional or volunteer context. The volunteer activities in the cities, in particular, show that the knowledge about the activities of the administration is considered to be easier and more understanding, while citizens who lack the knowledge in the first place state that the administration needs to perform more educational work accordingly. Thus, many sustainable innovations, such as major structural changes, energy-combining innovations, or building cross-interface data platforms, are considered to be highly complex.

*“The bike concept is actually relatively simple.” (M1-3)*

*“I would say greening bus stops is pretty easy.” (L2-4)*

*“[The complexity] I think is already high. Especially if I then want to use three products, e.g., hydrogen, oxygen, and the heat. Then, on the one hand, I have the challenge that one must set the pace, e.g., one of these three needs must say I need it now, and then the others must either take something, or it must be wasted. Getting a system like this up and running in the long run is quite complex.” (L2-3)*

*“The complexity of all the possible feeders that feed into a grid, to somehow keep the whole thing running, is becoming more and more complicated with all the possible new innovations that come along. Of course, this is also to the detriment of the power grid because it is becoming more and more complicated to control it. It doesn’t matter whether more power or less power is to be fed into the grid, because the fluctuations are getting stronger and stronger, and the grid will probably collapse at some point. At the latest then, and this is not only related to [name of city], but regardless the place, action must be taken.” (L1-1)*

Sustainable innovations from the *CE* and *RE* categories were predominantly seen as highly complex by the interviewees, and sustainable innovations from the *NA* category were seen as less complex.

#### 4.2.4. Trialability

Many of the sustainable innovations discussed can be tested by citizens. The knowledge about this is largely available, but for many projects, the citizens do not even know whether it can be tested, although the interviews with the administrations showed that there are offers for this. The interviewees have tested many innovations, and their resumé was always positive after testing. This shows that the administrations still have to perform more educational work because the results show that the respondents are positively enthusiastic about the offers after they have tested them, but, in most cases, did not know about them beforehand.

*“There’s bound to be something.” (S2-3)*

*“So only indirectly. You can just drive with the hydrogen buses. But for the user there is almost no difference to a normal electric bus, and they are only driven on a few very long routes.” (L2-3)*

*“In fact, there is, you can actually visit it. But because of the pandemic currently rather difficult. But otherwise there have always been regular tours of [the sustainable innovation].” (L1-1)*

*“Yes, I was still in the video conference last week for the launch of the [name] project along with a hundred other video conference participants.” (M1-3)*

*“I tested that a lot.” (L2-3)*

The sustainable innovations of the *NA*, *GO*, and *MI* categories could be tested by all interviewees. For the sustainable innovations in the *CE*, *ED*, and *RE* categories, half of the interviewees knew that they could be tested, and the other half did not know if they could be tested.

#### 4.2.5. Observability

The public relations work was described in many ways by the interviewees. The sustainable innovations were promoted analogously via newspaper, radio, TV programs, print media (flyers, posters, etc.), and events, but also digitally via social media, digital advertising, or newsletters. Depending on the age group, the appropriate publicity was noticed: the older interviewees drew their knowledge from newspapers and radio, and the younger interviewees knew more about Facebook, Instagram, posters, or by paying attention on the way to work.

*“No, I don’t think they do that. As far as public relations are concerned, they don’t do that very well, they could do it better. Because do good and talk about it! So, they don’t talk about it, but it becomes noticeable here and there, where someone donates, then they are usually in the newspaper with a big check.” (M2-2)*

*“[I learned] About the newspaper article.” (S2-1)*

*“And the [sustainable innovation] is also publicity-generating as a tourism magnet.” (L2-2)*

Overall, it depended a lot on the interest of the interviewees as to whether they were attentive enough to actively notice the public relations. However, upon further inquiry, many realized that they were aware indirectly of public relations. This can be seen in the two exemplary quotes, where one interviewee, L1-3, did not notice or perceive much of the public relations work, whereas the other interviewees from the city always cited this sustainable innovation as the best example.

*“So as far as public marketing is concerned, I’ve never read or heard anything. So, if you drive on the highway to [name of city], then you drive under the route. And that just such a big sign. There you see just this word [name of sustainable innovation], but otherwise have now not read somewhere times of it or a report about it.” (L1-3)*

*“Yes, there’s publicity everywhere. So, if you also go by car, everywhere this route goes and in the press it’s also a topic every now and then.” (L1-2)*

In comparison to the citizen’s view, the observability can be well contrasted with the administration’s view. The administrations try to position high-investment sustainable innovations strongly in the public sphere, as is exemplified here. The interviews with the administrations showed that, in most cases, they resort to their standard means of public relations, such as press releases or website entries. Throughout the COVID-19 pandemic, many administrations added social media as a way to reach more citizens. This has now also been intensified. However, it is evident that when the mayor communicates his or her work through analog and digital media, more citizens know about the (sustainable) innovations, and citizens’ satisfaction increases.

*“Yes, we held three or four large public events. So, on site actually in presence with the different experts we have explained that also in detail. We held a lot of consultations with building owners, which provided comprehensive information. We were constantly also in the exchange with the architects, if there questions had to be asked. We held a construction fair or two construction fairs, where we also got in touch with companies. Of course, press work etc. And finally, of course, about the prizes we received for it. Which then also got another publicity effect.” (S2-A)*

*“So now, for example, with the [name of sustainable innovation], there is a circle of 100 people who meet regularly and work on the topic. That is very well received.” (L2-A)*

On the one hand, in the GO and HE categories, all the interviewees perceived public relations as very intensive. All of them knew that sustainable innovations existed. Sustainable innovations from the MI category, on the other hand, were described as having very little publicity. For sustainable innovations in the CE, EC, and RE categories, public relations were perceived differently, ranging from very intensive to moderate to very weak.

#### 4.3. Decision

The majority of citizens have chosen to use sustainable innovations. The part of the active decision for sustainable innovations is higher than the inactive part. By active decision, we understand decisions that were made knowingly, and by inactive decisions, we understand decisions where the use is made unconsciously, but thereby an inactive decision is present.

*“I have been there since then for sure, but I did not consciously perceive.” (S2-2)*

*“Yes, I wanted to test it, but I’ve really never ridden them that much, unfortunately.” (L1-5)*

*“Yes of course I do it, as I see myself to leave the car as possible.” (M1-3)*

Compared to the administration, from the administration’s point of view, many sustainable innovations have been well received by the citizens. The administrations indicate this by the number of visitors or users (e.g., website) or by the inquiries about sustainable innovations, e.g., calls to the municipal clerks.

*“The interest [of citizens] is definitely there.” (S2-A)*

*“In the meantime, I think almost 2000 children have gone through this program. It’s now become a summer school as well. Two weeks of summer children’s recreation/vacation. Super successful and super nice story.” (M2-A)*

However, in just under one-third of the sustainable innovations, using innovation was also rejected. The reasons for this are mainly that there was no opportunity to use it, there was not enough motivation or incentive to use it, the sustainable innovation was still too insignificant, or it was unnecessary for the citizen because, for example, a car was already available and then no car sharing car needed to be rented.

*“No, actually it simply did not come to it, because the car stood here and that naturally also again, if one has one, one rents oneself naturally not still liable to pay the costs another.” (S2-1)*

*“Well, no. At that time, it wasn’t such a big issue. That was just a bit longer ago.” (M1-2)*

*“I don’t think so. I’ve driven electric buses several times and as far as I know, there’s actually no noticeable difference for the user. And since it’s supposed to be used on interregional routes or interurban routes, it’s not something that you could try out in everyday life. I never actually drive into the surrounding towns of [name of the city]. And now, just to try it out, it wouldn’t be worth it to me.” (L2-3)*

From the administration’s point of view, it is evident that in many cases, enormous efforts have been made to implement sustainable innovations, but the citizens have not noticed anything about sustainable innovations.

*“Only two teachers and two students came.” (M2-A)*

*“We planned an online event, but unfortunately only a handful of citizens came. We are currently still looking for the reasons.” (L2-A)*

The sustainable innovations of the NA, GO, and RE categories were always accepted and used by the citizens. Sustainable innovations in the EC category were increasingly rejected. The other categories were rather mixed.

#### 4.4. Implementation

The interviewees received the sustainable innovations as overwhelmingly positive. Many interviewees talked in detail about their experiences with using sustainable innovations. It became clear that the implementation of sustainable innovations brought many follow-up effects of a positive nature and greatly improved the quality of life.

*“In fact, [my acquaintance] says that many shipping companies are super happy when they get capacity in [name of city], because they also say that everyone who goes on a cruise also wants to pay attention to sustainability. Accordingly, [name of city] is now completely full. They don’t know where to go with all the ships, whether it’s ferries or cruise ships, so this has definitely had a positive effect on the port.” (L1-4)*

*“Yes, actually, in my circle of friends there are many scientists, and accordingly this comes up more often. And yes, so I think that is basically positively accepted. I think that if you don’t have the appropriate background, you might not know exactly what is being done there. But I think the attitude is basically positive.” (M1-2)*

*“Yes, I really do. And then just about that, yes, several people from my circle have also participated. And there is just also similar. That really goes down well, that you can inform yourself not only unilaterally, but can also contribute somewhere.” (M1-2)*

However, it was also critically illuminated that, especially in the environment of the interviewees, there was often ignorance or even disinterest in sustainable innovations. Complicating matters during this phase was the COVID-19 pandemic, as a result of which the use of some sustainable innovations or their promotion did not take place or did not take place sufficiently; accordingly, the use also failed to materialize.

*“I have the feeling that many are not interested at all. In other words, actively not at all. And that they would be absolutely flattened and overwhelmed by, for example, something like this sustainability concept, that they wouldn’t read any further if they saw A, it has 100 pages and B, it starts with such big things as the goals of the United Nations. I think that slays people who have nothing to do with it.” (S2-1)*

*“[. . .] to be honest, that was also due to Corona. We just didn’t meet that much. I didn’t meet any colleagues. That’s why it didn’t come up so much. I only talked about it with my girlfriend.” (L2-2)*

The sustainable innovations in all categories were described as positive by the interviewees. The view of fellow citizens was somewhat more critical or neutral. In the EC category, it was noticeable that a few projects were described as negative.

#### 4.5. Confirmation

The interviewees who indicated that they had a positive perception of the implementation also all intend to use sustainable innovations in the long term. The citizens are all interested in doing something about climate change, behaving more sustainably, and supporting the city or municipality. Therefore, the applicability to the citizens themselves and the positive perception of sustainable innovations play a large role in the innovations used in the long term.

*“I will go with it again if it takes place again [after Corona].” (L2-4)*

*“I personally would actually use it every day. Even if I have any appointment in the city now, I definitely use it too because you just avoid the opened, the traffic on the street.” (L1-4)*

*“Well, I think that’s a point that is becoming more and more important. So simply because we should do now also just so basically climate change, environmental protection, and other things there really what. Therefore, it also wants to use.” (S2-3)*

Sustainable innovations in the CE category are all used in the long term. The sustainable innovations of the NA, GO, and MI categories mainly do not need to be used in the long term.

## 5. Analysis of the Findings

For this follow-up study, we conducted a total of 29 interviews in six cities and municipalities, capturing both the perspectives of citizens and administrations. Based on the five stages of innovation by Rogers (2003), we examined to what degree citizens know and confirm sustainable innovations undertaken by their cities and municipalities [26]. What we found was distinct evidence that often citizens are not aware of sustainable innovations, or if they know about them (DOI stage 1), they do not progress towards adoption. Therefore, we presented the differences sorted by level per category (see Figure 2). However, the difference is also especially evident when comparing the citizens’ perceptions with those of the administrations (see Figure 3).

Across the categories of innovation projects, we also found distinct differences. CE innovations occurred across all five DOI stages. NA, as well as GO, appeared across the persuasion, implementation, and confirmation stages. And while ED emerged across all stages, EC appeared only in the first three stages. Here, the comparison to the municipality view with business innovations across stages 3–5 is worrisome. It appears that business innovations are specifically poorly perceived. For example, as detailed in the previous section, EC innovations were perceived as less compatible than other innovations. Here, a deeper investigation into the specific perception of each EC innovation and potential contextual factors would be necessary. MI appeared only in the decision and implementation stages, while a comparison to the administrative view demonstrates that they should already be in the confirmation stage. This is a finding that gives hope in light of recent refugee movements due to the Ukraine war. Apparently, innovations in MI create sufficient awareness. RE appeared across all DOI stages, not reflecting the large number of sustainable innovations already in the confirmation stage from an administrative view. The reason might lie in innovation characteristics as described in the last section, e.g., that half of the citizens were not aware of its trialability. Finally, HE innovations were exceptionally well received and appeared only in the confirmation stage, a finding that only underlines the effect of public relations efforts. Citizens perceived that these were exceptionally well communicated, as described in the previous section. These differences across categories raise concerns and should also caution administrations to increase their activities to promote specific types of sustainable innovations.

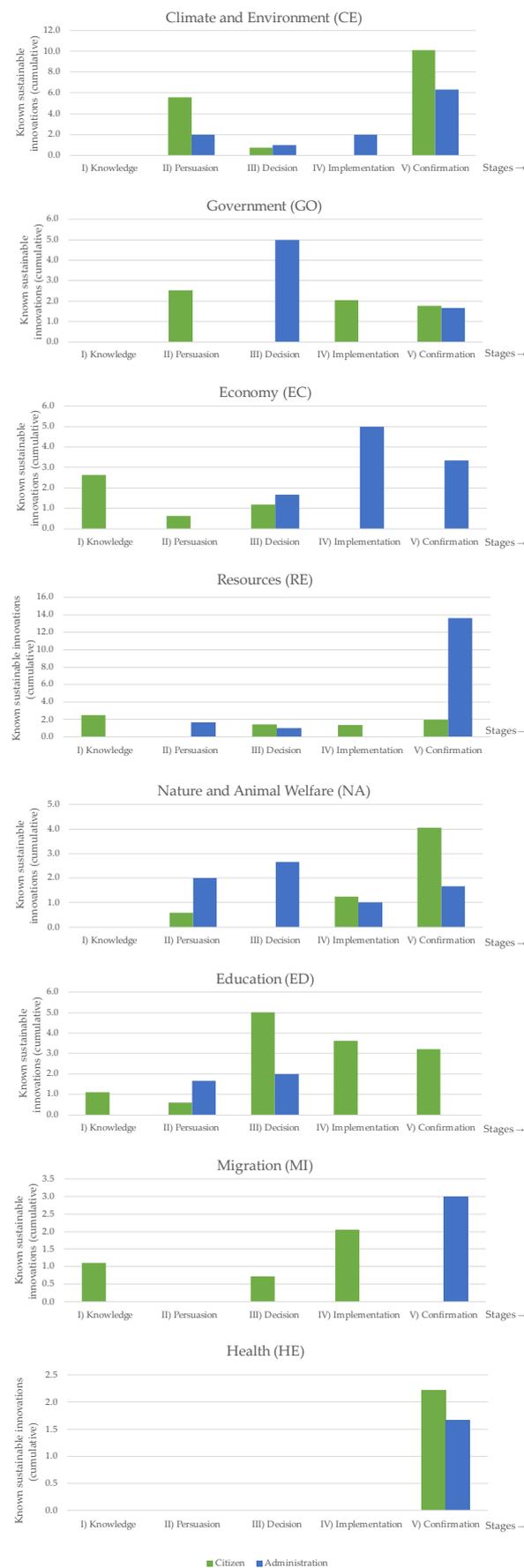
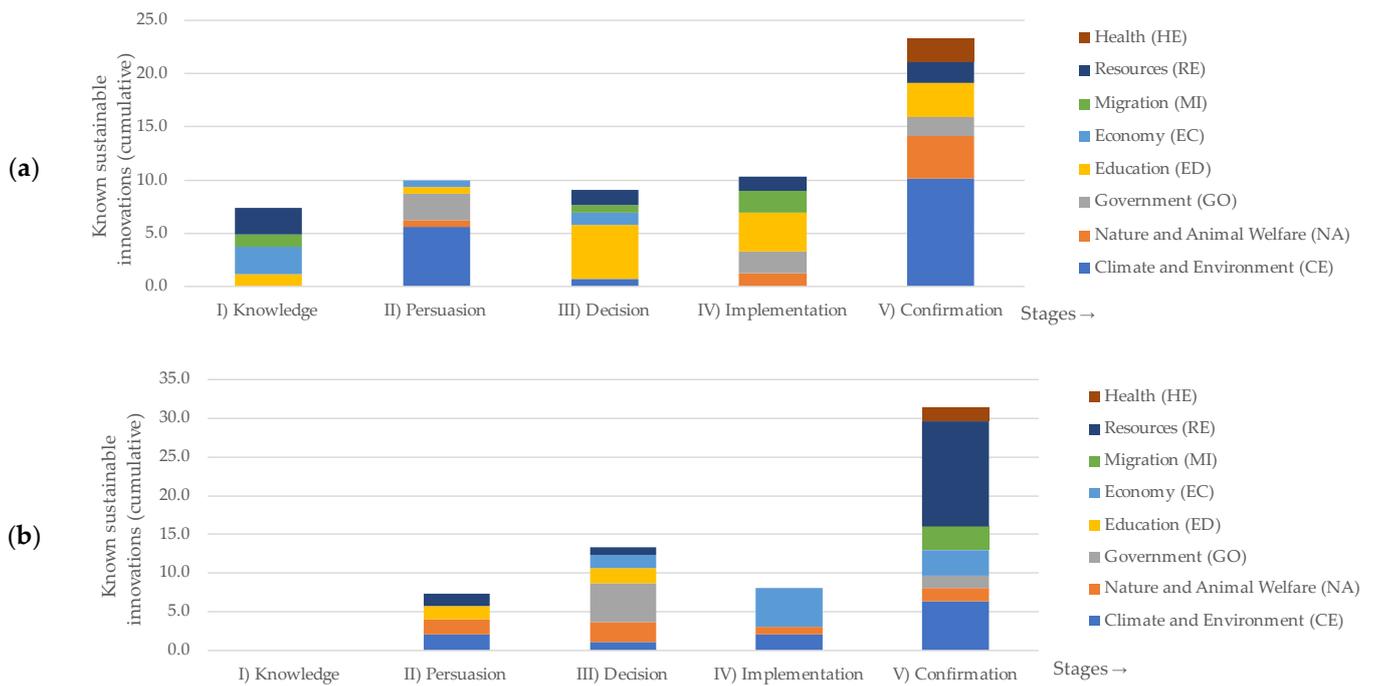


Figure 2. Diffusion of sustainable innovations per category.



**Figure 3.** Diffusion of sustainable innovations as perceived by citizens (a) and by municipalities (b).

## 6. Discussion

After analyzing the results, it appears that across cities and municipalities, we found a multitude of best practices ranging from the active use of social media to promote sustainable innovations to formats for citizens' participation (e.g., S1-1 to S1-3). Our interviews with the administrations' representatives indicate that there is still room for further best practice sharing, in combination with our findings across the innovation categories.

Regarding the size of cities or municipalities, we found no effect. The awareness of innovations was similar across all localities. Rejection and adoption decisions also appeared equally distributed. Apparently, citizens' reactions depended more on the specifics of each locality. For example, we found only rejections of innovations in one middle-sized city (S2-1 to S2-3). In comparison, both a small municipality (M1-1 to M1-4) and a large city (L1-1 to L1-5) showed an equally mixed picture of rejection and full adoption of innovations (DOI stage 5). Instead, we found that individual influences were much more decisive. While age, marital status, number of children, education levels, and IT affinity had no influence, gender had a slight influence: Women exhibited a larger readiness to adopt innovations. Such a higher adoption readiness is in line with prior theory, which shows that adoption readiness differs with gender and is higher depending on gender [35]. For example, Ahuja and Thatcher (2005) found that women were more likely to innovate with IT [31]. We also observed that individuals whose job or voluntary engagement brought them in contact with sustainability aspects were more likely to be aware of projects in their municipality or city (e.g., M2-3, M1-2, M1-4). This is not a surprising finding in itself, but municipalities could further target these individuals as multipliers or agents of change. A concept that already works in the context of other change efforts, as Markus and Mao [36] showed, and that could also help to promote knowledge on sustainable innovations.

### 6.1. Theoretical Implications

Our findings have three main implications for theory. Firstly, we have modeled the adoption process for sustainable innovations in the public sector by successfully adopting the DOI framework to this novel context. Thereby, we address the current lack of studies on innovation adoption in the public sector, which includes the citizens' perspective. So far, studies have only focused on the public sector organizations themselves. As previous

research demonstrated, the public sector has specific characteristics, such as the higher need for reliability and security, which are especially important in the interaction with citizens [37]. Nonetheless, we were able to demonstrate that adoption decisions and patterns follow similar structures as the ones initially defined by Rogers (2003) [26]. The adoption of the existing DOI framework allowed us to increase scientific understanding of the process in the public sector context. We were thus able to extend both the knowledge base in the innovation as well as the public sector research. Based on this understanding, we were able to further examine additional factors, such as the influence of innovation category, city size, and individual influences. These factors allow an even more detailed understanding of adoption processes. The categories we established could provide a first step in that regard. Secondly, our dual perspective of citizens and administration members offers more in-depth insights. This approach was developed to account for the unique environment of the public sector—no other organization is as accountable to users or consumers [38,39]. However, future researchers might also adopt this procedure of interviewing both people introducing the innovation and those adopting it for other contexts. Our study demonstrates that the two perspectives vary greatly. Thus, focusing only on one perspective cannot deliver a full picture of the innovation's perception. Hereby, we add to the methodological toolset around the DOI framework. The method that we successfully employed could also be used to examine different software solutions, e.g., virtual reality, capturing both the perspective of the consumer and the vendor. Finally, we also extended green IS by establishing a process model for innovation adaptation in relation to sustainable innovations. Here, our differentiation by innovation cluster allows further insights. The innovation categories themselves are hereby highly specific to public sector innovations. Differences between types of innovations, for example, process innovations [29], are readily available, but for further sustainable innovations, more general categories are still missing. This distinction allows for further questioning of variations or typical patterns in the overall process caused by specific characteristics of innovation projects in a specific cluster. For example, the lack of attention to innovation projects around business topics points towards the general societal discourse that can also influence innovation perception.

## 6.2. Practical Implications

Moreover, these findings have very concrete implications for practitioners. First and foremost, they provide much-needed feedback to cities and municipalities about the diffusion of their sustainable innovations among citizens. The evident discrepancy between citizens' and municipal administration's perspectives in our data should encourage those engaged in sustainability innovations to go even further to ensure adoption. Our interviews with administration representatives demonstrated that the reasons for the lack of adoption are often unclear. The systematic assessment across DOI stages should open up opportunities to identify issues and increase adoption rates. We examined only a few cities and municipalities that received the GSA. Based on our framework, a simple replication with a series of interviews can be conducted either by an external (neutral) party or by administration representatives themselves. We believe that a similar examination could also benefit innovation programs in other municipalities and cities that might not (yet) have received the GSA. Secondly, our findings regarding innovation characteristics demonstrate that relative advantage, compatibility, complexity, trialability, and observability of innovations need to be ensured. For example, the finding that only half of the citizens for the innovations in the categories CE, ED, and RE know that these were available for testing should encourage further activities to propagate this knowledge among the citizens. However, these aspects should already be considered at the conception stage of (sustainable) innovations. Ensuring that all characteristics that guarantee innovation adoption are planned for, e.g., planning for testing and actively communicating that. Finally, the differences across innovation categories demonstrate that administration representatives should be especially careful to promote those innovations that pertain to a category that

is more often overlooked or less visible in citizens' daily lives, e.g., EC innovations. Our follow-up study offers a first starting point for practitioners to examine their portfolio of innovations and to focus especially on the critical categories we identified.

## 7. Conclusions

Our research shows implications for both theory and practice and thus contributes significant value to society. As sustainable innovations matter to people, it is increasingly important to understand to what degree citizens know and confirm that their cities and municipalities are implementing sustainable innovations. Our findings show that municipal administrations mostly struggle with the fact that citizens do not accept the (sustainable) innovations—the reasons for this, however, are often unexplained, and the municipal administration has no knowledge about the reasons for the lack of acceptance and how they can act against it. Our findings show that municipal administrations need to make their (sustainable) innovations more visible. As a rule, citizens lack knowledge about (sustainable) innovations and their content. The more citizens are informed through various channels and involved in the processes, the more likely they are to accept the (sustainable) innovations. As with other research, ours has some limitations. Our research is based on qualitative data. We interviewed a total of 29 people from six cities and municipalities. Considering this background, we urge future researchers to collect more data. Our findings are based on a non-random and non-representative sample. Against this background, the findings may be biased and, therefore, cannot be generalized to the entire population of German cities and municipalities. It would be more useful to collect broader data from several cities and municipalities of the same size. We randomly selected two cities from each of the small towns, medium-sized cities, and major cities and spoke to an administrative employee and individual citizens accordingly. We suggest that future studies increase the survey by the number of people interviewed and survey more than two cities and towns from each area to increase the chances of reaching more respondents in order to generalize. Furthermore, data can be collected across national borders to show the differences between Germany and other countries.

To further advance our research, in the next phase, we will build on the findings of the follow-up study to formulate hypotheses and test the findings of the subset in a survey study with all 27 winning cities to precisely counter the limitations. The objective is to compare the sustainable innovations of the cities and municipalities surveyed with others for each category. We want to find out if there are sustainable innovations in a category that have the same level across all city sizes or if sustainable innovations in a particular category correlate with the city size. Finally, we will try to find the factors and barriers that explain stage change.

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