Towards IS-enabled Sustainable Communities – A Conceptual Framework and Research Agenda

Full Paper

Benjamin Brauer
Georg-August-Universität Göttingen
bbrauer@uni-goettingen.de

Lutz M. Kolbe
Georg-August-Universität Göttingen
lkolbe@uni-goettingen.de

Abstract

The trend of urbanization leads to several environmental problems such as shortage of resource, pollution, and rising carbon emissions. In the smart city context sustainable communities are considered as promising measures to tackle these issues. The technological evolution of the recent years offers versatile opportunities to convince people in their behavior and the potential of information systems to support ecological improvements gains increasing importance and interest in research. In this paper we propose a theoretical framework for the design of citizen-centric environmental sustainable information systems to build sustainable communities in smart cities. The framework considers theories and counter measures from psychological, social, environmental, and IS science to create a holistic architecture for green IS implementations. The goal is to drive further research and practical implementations in this domain.

Keywords

Green IS, smart cities, sustainable communities, user-centric framework.

Introduction

The population density has been increasing over the last decades and the trend of this development prevails; more and more people live in cities rather than in sub-urban areas (McDonald 2008). This trend, generally referred to as urbanization, brings several problems with it, especially regarding environmental concerning issues (McDonald 2008; Washburn and Sindhu 2009). In order to address the imminent shortage of resources and increasing carbon emissions, several counter measures are already considered. Despite the obvious actions of acquiring more resources (e.g. water, energy sources) and lowering carbon emissions by introducing Co_2 friendly appliances (solar-powered light systems) or modes of mobility (e.g. e-Busses), alternative measures gain increasing importance. A very promising way to reduce the negative impacts of higher population numbers in urban environments is by influencing people's behavior (Kollmuss and Agyeman 2002; Kurz 2002; Stern 2000). At this point cities and their inhabitants can have a major effect when the organization of sustainable communities takes place (Lövehagen and Bondesson 2013; Portney 2005).

In the context of smart cities the denotation 'smart community' is often used to conceptualize the basic idea of sustainable communities. Although the definition of a smart community is more comprehensive. Smart communities inherit their properties from the general description of what constitutes smart cities. While there is no unique and overarching definition, there are three key factors that can be referred to as fundamental components. A smart city encompasses technological, institutional, and human factors (Nam and Pardo 2011). Thus, smart communities have a strong bond to governmental instruments and policies and aim for generating knowledge and creativity. In this context information technology plays a vital role to supplement the required processes and underlying infrastructure (Bengtsson and Ågerfalk 2011; Nam and Pardo 2011; Tranos and Gertner 2012). Sustainable or smart communities are composed of different neighborhoods and interest groups sharing their ideas on sustainability relevant topics and engaging in collaborative activities to reach a common goal (Nam and Pardo 2011; Xia et al. 2014).

On one hand, citizen-centric application of information systems (IS) has barely taken place in IS research regarding environmental sustainability in the city context (Brauer et al. 2015). On the other hand, cities deploy user oriented information systems to offer easier accessible or additional services to their citizens to make governance tasks more comfortable and to increase the quality of life as well as to optimize internal processes (Neirotti et al. 2014). In addition, pervasive mobile technologies such as smartphones, tablets, and wearables offer plenty opportunities to persuade and influence individual's user behavior (Woodruff and Mankoff 2010). In the smart city context the city can take a moderating role to connect users (citizens) and possible additional partners (businesses) as sponsors into a sustainable community with the goal to improve environmental sustainability. Therefore, the city can serve as a platform (Walravens and Brussel 2013) for initiatives, and communication for collaboration by utilizing information technology to trigger behavioral changes of their citizens. As it is the case in various application areas where pursued goals do not directly add to the user's own profit, mechanisms are required to motivate the potential participants and to drive engagement with long-term positive effects.

In this paper we provide a theoretical framework that helps create a holistic approach towards the creation of city-wide sustainability related campaigns through the help of their citizens. The framework considers multiple actors and system architecture in the context of environmental sustainability. The long-term goal is to encourage the development of green IS in the smart city context focusing on every individual, but also to incorporate partners from business and industry. Moreover, we present a research agenda for future studies in this area to drive further development of user-centric sustainable IS-design for sustainable communities.

Barriers and Influencing Factors of Eco-Sustainable Behavior

Before we discuss the opportunities for improvements on environmental sustainability provided by information systems, we take a deeper look in the theory behind environmental sustainable behavior in order to identify the prevalent problems which are often faced in this context. The discrepancy between environmental concerns of individuals and their final engagement in environmental actions is often referred to as value-action gap, and describes the prevailing issues in-between the two states of worrying about the environment and appropriate performance (Barr 2007; Blake 1999; Flynn et al. 2009). These inherent barriers are divided into an individual and social context comprising factors that prevent a person from acting sustainable based on their personal characteristics but also institutional circumstances and the influence of other people (Blake 1999; Kollmuss and Agyeman 2002). Gifford collated an extensive and thoroughly list of psychological barriers (see Table 1) that play an important role for environmental sustainable behavior change (2011).

Barrier	**Description**
Limited cognition	Limited knowledge about the state and threat of climate change, which leads to uncertainty about taking action and serve as a justification for inaction. This causes people to doubt their perceived behavioral control and self-efficacy regarding the outcome of their actions.
Ideologies	Some people hold a view that nature will go its way and does not need human intervention. Others are content with their lifestyle and cannot see how a change in their behavior could have any positive impact on either their or the life of others. Likewise, some people expect that there will be technological solutions soon that solve the prevailing ecological problems and that further personal efforts are a waste of personal resources (e.g. time or money).
Comparison with others	People compare themselves with others in nearly every life situation (Festinger 1954). If social peers do not comply with one's sustainable behavior it can lead to undesired and unexpected negative response and result in damage of reputation, self-esteem, and self-confidence (Corral-Verdugo et al. 2014). Moreover, if others do not act sustainable it may arise the question why one should engage in a more sustainable lifestyle to make the world a better place (Corral-Verdugo et al. 2014). Contrary, social interaction can have the opposite effect. If other people around oneself act sustainable, the pursuit of such behavior can become desirable (Lindenberg and Steg 2013).
Sunk costs	Past behavior may be connected with costly investments, e.g. for household appliances. Thus, past behavior and investments can be considered as sunk costs, if a more or less sudden behavioral change impends.
Discredence	Many people share the opinion that climate change does not exist and distrust governmental

	and scientific statements about climate change and its impact. This can lead to the belief that climate related programs are useless or inadequate and create mistrust in governments, programs, and even other people.
Perceived risks	There can be doubts about the effectiveness of actions taken, e.g. due to limited knowledge or certainty. Hence, the person might question whether financial investments in a more ecological appliance is worth it or if the outcome of an action satisfies the time spent.
Limited behavior	The belief that other countries or places have a higher share of the negative ecological impacts can lead to a lower willingness making an effort. The same applies for a lack of identification with the place where a person lives and their community. Additionally, rebound-effects can occur, e.g. the purchase of a more sustainable car results in more car-use or inefficient driving because it is thought to be sustainable.

Table 1: Psychological barriers of sustainable behavior

Generally, these factors can be assigned to the categories *individuality*, *responsibility*, and *practicality* (Kollmuss and Agyeman 2002). The individuality-dimension covers barriers that arise from the characteristics of a person, their attitudes, and temperament. Responsibility encompasses factors that make a person believe that s/he has no influence on the ecological situation and should not be in charge of taking actions. The reasons are manifold and originate from a lack of efficacy, trust in others, or limited (perceived) possibilities. The practicality-dimension describes institutional and social limitations, e.g. a person might not have the financial or temporal capacity to act sustainable. Respectively, there can be a lack of fundamental and valuable information or encouragement (Blake 1999; Kollmuss and Agyeman 2002). All these psychological factors are also influenced by personal circumstances as mentioned above, e.g. financial risks. Personal factors like income, household size, age, educational level and even gender can affect the success of behavioral change efforts (Fogg 2009; Zhang et al. 2015).

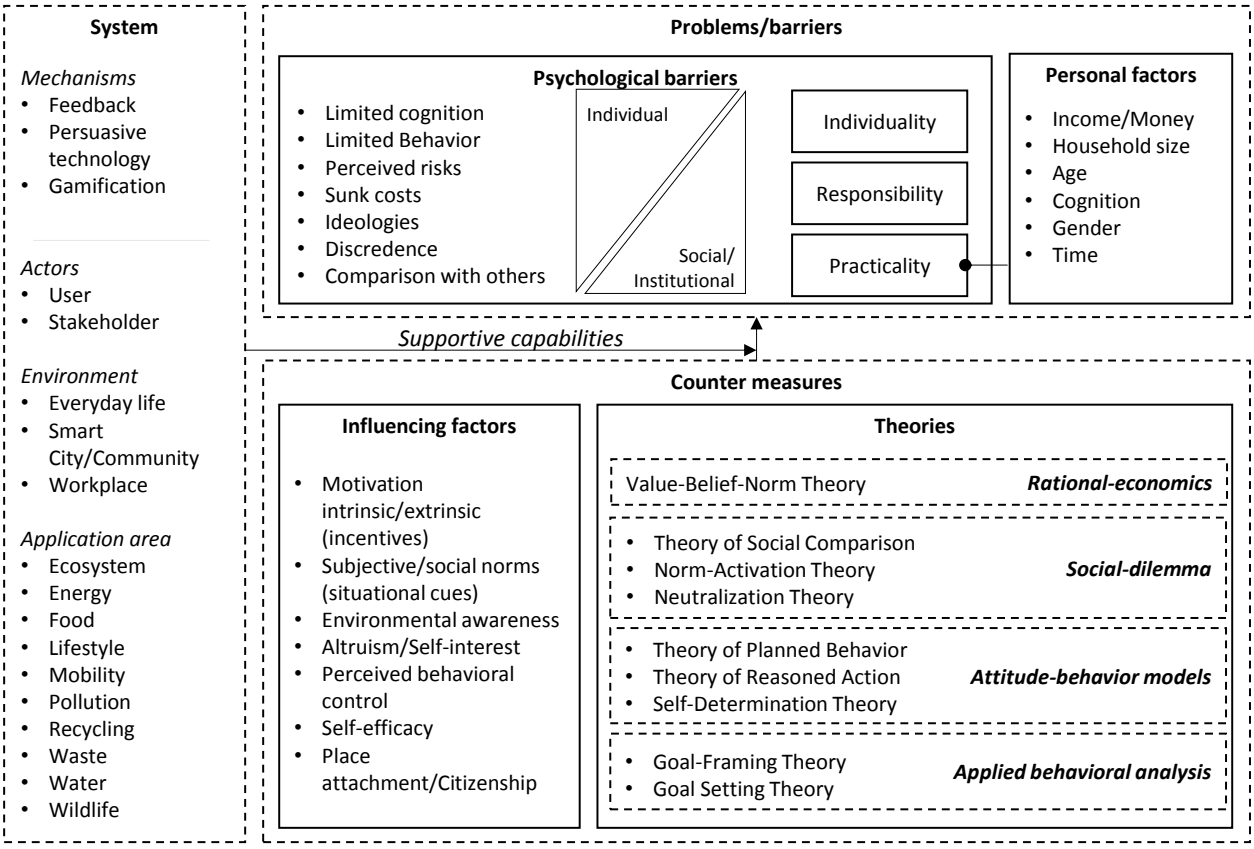

Figure 1: Problems and counter-measures of environmental sustainable behavior

Psychological, social, and environmental science covered the topic of environmental sustainable behavior change in great extent during the last years and it became an extensive research field. Particularly the

theoretical perspective is well-studied due to the application of various theories to explain and predict behavior change processes. Figure 1 illustrates the complexity of the driving forces behind environmental sustainable behavior change approaches with an overview of applied theories in the context. The theories are attributed to the four general psychological approaches of environmental sustainable behavior (Kurz 2002). It would be inappropriate to label a theory or concept improper because it does not hold for a certain case; what works for some people might not necessarily work for others and vice-versa. Thus, concrete implementation should always consider conflicting theories and concepts. A theoretical concept of this circumstances has been applied in the ecologic-behavior context in form of the goal-framing theory (Lindenberg and Steg 2013). The theory states that individuals have manifold goals and expectations regarding their behavior. An intervention should ideally address the normative-, gain-, or hedonic goal-frame. Hereby, a person's motivation is activated based on his/her preferences, e.g. monetary/health benefits (gain), fun/well-being (hedonic), or the targeted purpose (normative, e.g. environmental sustainability). On a more specific level regarding goal-achievement, the goal-setting theory argues that quantifiable goals should be variable and geared to individual's cognitive and institutional possibilities (Locke and Latham 2006). Otherwise, motivational potential is lost and future engagement is in danger.

The existing theories give a very good idea about what factors need to be considered for successful behavior change interventions. The goal of IS-based solutions should be to take advantages of the identified influencing factors (see Figure 1) and address the psychological barriers given above as substantial as possible. The following section discusses suitable approaches where IS can offer a good contribution to build sustainable communities.

Towards an IS-Enabled Framework for Sustainable Communities

In this section we propose a theoretical framework for the design of eco-IS to support the establishment of sustainable communities with the goal to trigger sustainable behavior change of people. The design is not targeted on specific technical implementations but rather takes a holistic view. Besides the presentation of concrete examples to tackle the prevailing issues of the psychological realm, we focused on this area from an organizational perspective. Figure 2 illustrates the conceptual design of the proposed IS-based framework (System) as introduced as a supportive measure in Figure 1 (left-hand side).

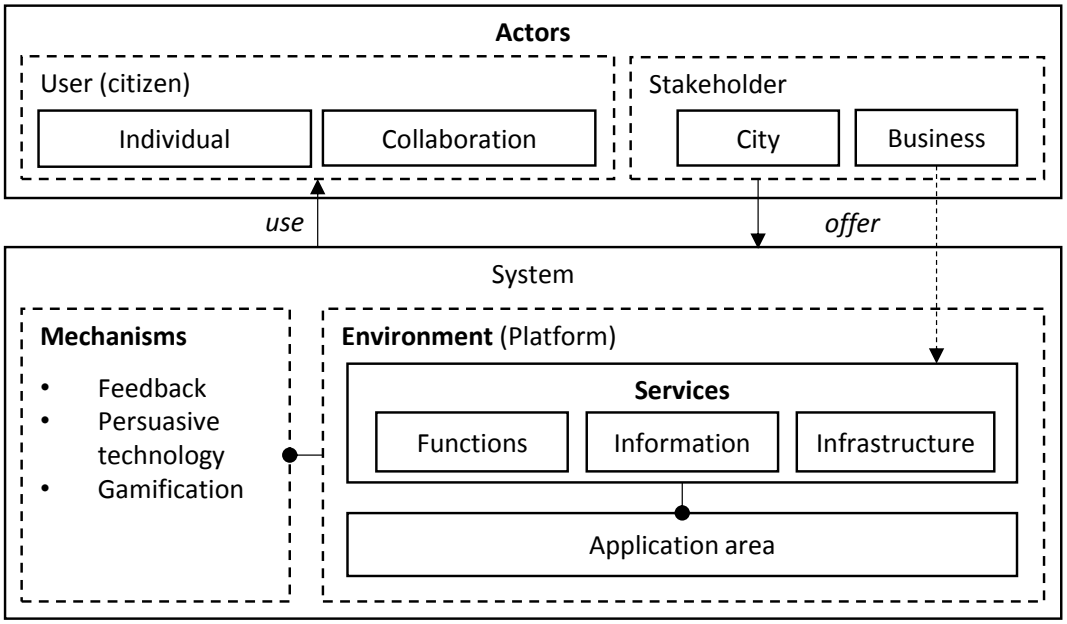

Figure 2: Framework for IS-enabled sustainable communities

The single components of the framework and their interaction with the influencing factors from theory as well as their potential impact on the psychological barriers are discussed in the subsequent sections.

Components of the Framework

The proposed framework consists of four key-components: *Actors*, *Environment*, *Services*, and *Mechanisms*. The actors are divided in users and stakeholders, where stakeholders provide a system to foster environmental sustainable behavior of users. The institution that offers the system should be centralized, trustful, and able to reach a large group of people. As mentioned above cities have potential to create communities. Since it is always the goal of municipal governments to improve local sustainability (Kutami 2014), they should take a leading role for such initiatives by serving as a platform for their citizens (Walravens and Brussel 2013). However, cities often do not have the funds or technological competencies/infrastructure to run such initiatives on their own. Consequently, it is commendable to cooperate with local partners from the business or industrial sectors.

The environment describes the service platform integrating all available sustainability interventions and serves as the interface to the user. It can be implemented as a browser-based web-application, a mobile application for smart devices (smartphone, tablet, or smartwatch) or a combination of both. Each single service has a dedicated purpose and is a discrete module inside the platform. The platform – or runtime-environment – provides the interfaces required to easily add additional service modules. The advantage of this architecture lies in its flexibility and centrality. Equal to an online-marketplace like Amazon, a centralized platform could positively contribute to the diffusion of sustainable IS-solutions and a rise of awareness (Ghazawneh 2010; Walravens and Brussel 2013). Furthermore, the distribution of innovative sustainable IS will be simplified.

Services running within the environment are sets of functions, information, and infrastructure required to offer a sustainable intervention. They are attributed to a specific application area (see Figure 1) like the mobility sector and use different mechanisms to drive user engagement – the supportive capabilities of appropriate mechanisms are discussed in the next section. The environment-service architecture allows partners from business and industry to offer their products in a very comfortable fashion. An electric utility company, for instance, could sell smart-meter products and use the prevalent platform to offer a service module to let the costumers monitor, compare, and eventually adapt their consumption behavior, and by this reach more people or potential clients. While this sounds inconsistent with the company's goal to sell power at first, it could add additional value to the service of power supply, and in this way lead to higher customer satisfaction and retention (Kuo et al. 2009).

In order to design the service modules as sustainable interventions they require appropriate functionality. Hence, the selection of proper mechanisms is crucial for the intervention's success regarding the prevailing psychological barriers. Green IS research examines the capabilities of information systems as contributor to environmental sustainability (Vom Brocke et al. 2013). Nevertheless, the mainstream of research focuses on business related topics such as sustainable production and supply chain management and less on the public sector (Brauer et al. 2015). The existing literature in this area primarily addresses two application domains: energy and transportation. In the transportation domain such solutions aim to influence the driver behavior regarding fuel efficiency by providing feedback about the impact of driving behavior on fuel consumption and the resulting Co_2 emissions (Tulusan et al. 2012). Other approaches use IS based interventions and feedback mechanism to promote sustainable mobility alternatives such as bike usage (Flüchter and Wortmann 2014) or provide solutions to track their overall mobility behavior as a combination of different modes of mobility and give information about the total ecological impact of the applied mobility behavior (Froehlich et al. 2009). In the energy domain smart meter and information systems are run to track and visualize energy consumption of households. These applications are utilized to persuade users regarding their energy consumption behavior and examine the effects of social normative feedback on electricity consumption by the consumption-comparison of e.g. neighbors or friends (Loock et al. 2012). Besides the utilization of feedback- (Flüchter and Wortmann 2014; Loock et al. 2012) and persuasive systems (Oinas-kukkonen and Harjumaa 2009), gamification can be used to motivate and incentivize sustainable behavior and community collaboration by IS (Flüchter and Wortmann 2014; Lounis and Pramatari 2014).

Supportive Capabilities of Information Systems

The prior sections give an overview about the complexity of the field of environmental sustainable behavior. Building sustainable communities is a complex task. Based on existing research we identified

two central areas which are discussed in the following. First there is the need to drive engagement for sustainable behavior on an individual level and second, the promotion of social collaboration. These two scopes are not mutually exclusive but rather complement each other. The motivation of people towards engagement in sustainable activities is not an easy task and there is no blueprint for the perfect solution because people are different. As the theory shows, there are many factors that have an impact on a person's attitude and ultimately on behavioral change. However, as indicated above, IS can have huge potential to overcome the prevailing barriers by facilitating the factors that can have a positive influence on people and help to convince them towards more sustainable behavior. A major problem concerning environmental sustainability is that many people are not aware of existing problems and the impact of their behavior on the environment. People need information; but it is hard for them to find suitable solutions if the problem is unknown. Thus, a holistic sustainability oriented information system could provide all the information necessary and help to understand the situation. Existing literature on the application of IS in the ecological context provide three approaches to address this issue: sole information provision, feedback on personal behavior, and persuasion (Flüchter and Wortmann 2014; Froehlich et al. 2010; Tulusan et al. 2012). The most basic way to tell people what is sustainable or not, and what sustainable behavior could look like is by providing general information. This could be guides, articles, life-hacks, etc. actively consulted by the user or passively provided by, e.g. social media. While this could be very helpful in terms of effectiveness, the existing psychological barriers are very likely to cause a person to refrain from engagement. The information might be given but a person does not belief that s/he can have a positive impact on the environment (Gifford 2011). This can be covered with the implementation of feedback mechanisms to monitor, evaluate, and report user-behavior (Froehlich et al. 2010). This approach enables an interaction between the system and the user and can address several barriers that sole information provision cannot achieve. Personalized feedback can trigger awareness about own behavior (Loock et al. 2013) and foster self-interest in personal decision processes (Gifford 2011). A person can view the impact of her/his actions in numbers, e.g. the amount of CO_2 saved by using sustainable travel modes (Froehlich et al. 2009) or visual, e.g. by the use of augmented technology to show air quality (Kim and Paulos 2009).

Nonetheless, for some people ecological goals have minor importance but this does not mean that they would not engage in sustainable activities by any means. As the goal-framing theory suggests, people have varying objectives and therefore require different motivational processes to trigger their interest (Lindenberg and Steg 2013). Accordingly, as an example, a service module for sustainable mobility alternatives should not only provide feedback about the amount of CO_2 emissions saved but also about potentially saved money compared to individual car-ownership or fitness related functions for e.g. bike-use to promote health-related motives. The pursuit of one of these goals different from the sole aim to reduce CO_2 emissions implicitly leads to the same result and therefore a positive impact on the environment. This can happen without having the person know that s/he engaged in sustainable activities at all and hence does not result in a burden for this person. Basically, an implementation of a service module should always consider a way to shift the intrinsic motivational aspects towards individual personal characteristics in order to reach a broader target group.

Another common way for motivation is triggered extrinsically and often instantiated through incentives (Barr 2007). Incentives can have many faces: materialistic, solidary, and purposive (Zald and Ash 1966). Since materialistic incentives like money or goods are always hard to realize because the unavailability of necessary funds – especially in a context like environmental sustainability –, solutions should focus solidary and purposive implementations. In the recent years gamification has been proven to be a successful mechanism to trigger motivation in various areas such as education, work, health, and sustainable consumption (Hamari et al. 2014). Gamification uses game-like elements in non-game contexts (Blohm and Leimeister 2013; Hamari et al. 2014), e.g. high-score/ranking lists to trigger competition, collecting badges/virtual rewards, and many more (Hamari et al. 2014). Besides individual motivation gamification also helps to foster social collaboration among communities (Lounis and Pramatari 2014). People can work in groups to e.g. become a winner of a competition. Moreover, people see the actions and the amount of actions performed by others. These can lead to situational cues where people recognize sustainable behavior in their area and makes it more likely that they also engage in sustainable actions (Lindenberg and Steg 2013) to participate in positive behavior and contribute to the community. In this context cities can benefit from their urban structure. Studies showed that sustainable behavior of people is more likely to take place if they feel an attachment to their environment (Pol 2002),

e.g. a village, city district, or local community. A system could utilize this factor and give information and feedback about sustainability related topics in people's vicinity. Furthermore, in the context of gamification, tasks or missions could be assigned inside the system using incentives, e.g. awards, badges, points, etc. and trigger a sustainability competition between different areas.

However, motivation alone is not necessarily sufficient to engage people in the desired behavior (Fogg 2009; Mustaquim and Nyström 2014). Personal factors such as lack of time, limited financial resources, cognition, etc. play an important role regarding the ability of people to engage in certain tasks or behavior (Fogg 2009; Zhang et al. 2015). A system aiming to persuade people towards a certain behavior has to make sure that their abilities are met (Fogg 2009). System design is crucial and can help to overcome personal factors which information, feedback, or motivational mechanisms cannot address. As time can be a very scarce resource, an application must be simple and fast to use – complex menus or excessive input should be avoided (Fogg 2009). Same applies for e.g. monetary and cognitive needs, since the potential users are very diverse in terms of age or educational level. Thus, some people might not have the funds to perform certain action or do not understand what is to be done (Fogg 2009; Mustaquim and Nyström 2014). When fundamental motivation is given and the right measures to care for the user's ability are applied it can still be necessary to trigger an action to engage the persuasion (Fogg 2009). Examples can be drawn from fitness and health applications that are frequently used nowadays, where a user receive e.g. a message prompt to get up and walk a few minutes (Cercos and Mueller 2013) or to eat healthy (Purpura et al. 2011). Such triggers can be incorporated with feedback information, e.g. if the amount of water-use is very high compared to recent behavior or others in the area – maybe a behavioral adoption should be considered; or the gamification mechanism, e.g. in form of a mission to collect extra point for a person's area by riding a certain distance by bike. This could motivate a person to take the bike to work instead of the car which was probably the initial intention.

Summary and Outlook

This article provides a design pattern with key components that can be considered in the design phase of an application aiming for ecological behavior change with a user-centric perspective. Existing research shows that it is important to address psychological barriers, influencing factors, and design principles given above for better results regarding behavioral change. Contrary to the corpus of existing research in this area we focus on forming sustainable communities. As shown above, this includes a combination of individual concerning attributes as well as for the interaction of people, groups of people, and their interaction with their environment. This encompasses not only governmental infrastructure but also business and industry. Hence, our goal is to include these actors and environmental characteristics into the framework. We argue that a holistic solution in a centralized municipal context can have higher potential than a diffusion of loose individual applications with different characteristics in various domains. However, this assumption has to be investigated.

While the underlying theory and their application in the context of sustainable behavior has a long history – their application and research in the IS domain constitutes a rather young field. Some approaches have already been made but their application is still limited to only few – yet promising – areas such as the energy and transportation domain. Nevertheless, there are more areas where citizen-centric information systems can have huge positive impacts on the environment, e.g. waste-management (recycle, reuse, reduce), life-style, water-usage (equal to energy consumption), and more. In the following we propose an agenda for future research in this particular domain of IS-use to foster sustainable communities in the context of sustainable (smart) cities.

- The sheer complexity of barriers and influences are obstacles for concrete practical implementations. This poses a challenge for future research in this area. It is wise to break down single thematic problems into smaller parts as prior research already did for single theories, mechanisms or interaction between user and system (HCI). However, future research should also consider the implementation of various approaches in parallel and examine them regarding synergy and exclusion. This will help to create more precise design patterns for future implementations. In this context more research should focus on the acceptance of such systems. This includes the consideration of various context-factors such as the role of place attachment, different combinations of motivational mechanisms, or social aspects. We encourage as well the investigation of other theories from different domains and their applicability in this context.

- For building sustainable communities, the later point is of great importance. While some studies examine social norms in their research models (Steg and Vlek 2009) or use social components inside an artifacts (Flüchter and Wortmann 2014; Froehlich et al. 2009; Loock et al. 2013; Tulusan et al. 2012) the concrete effect of social factors is yet unsought. Future research should examine the positive effects of social elements as well as their drawbacks. How can social components like social-media, interaction, or collaboration contribute to environmental sustainability? Is there a word-of-mouth effect? What is the role and potential of IS? In addition, it is interesting to find out if the positive effects can overcome the negative effects of social norms, and what practical implementations could look like.
- In this article we accord great relevance and potential to cities and their role as platform operator and moderator of an initiative. Forthcoming studies should aim to examine the abilities of cities to take that role and whether there is a positive effect of this construct opposed to the implementation of single independent solutions. As we sketched the role of partners within the framework, we urge researchers to find solutions how business and industry could be integrated within this context. Important questions include the willingness of enterprises and local businesses to engage in such initiatives and their role as promoter or supporter, e.g. by offering incentives/discounts to users.
- Incentives and motivational mechanisms play an important role as stated above. However, in the context of environmental sustainable behavior and the characteristics of this framework research should examine the suitability of implementations in this particular scenario. Different mechanisms could work or fail in varying application domains. Studies should evaluate the effect of materialistic, solidary, and purposive incentives. While the goal is to establish implementations that require little to no financial input, alternative options are also of interest if first said will not work. Micro-payments as used by Google for their survey app (Geidner and D'Arcy 2015) could be an interesting approach, especially if the preceding point about business integration is feasible. Bitwalking[1] for instance pays their users money (bitwalking dollars) for recording their walked distance with their app. The currency can be redeemed in a dedicated online store for various goods. For non-materialistic motivation gamification has been discussed within this paper. The gamification mechanism offers several dynamics to initiate motivational processes. Only little research has been performed about the suitability of certain implementation so far and deeper investigation is required. Moreover, other approaches might exist that have been implemented in other areas successfully. Interactions of different approaches are also of interest, e.g. the combination of gamification as a motivator and micro-payments as an incentive.
- Finally, we want to encourage more practical work in this field with concrete implementations. This encompasses specific implementations to evaluate, e.g. the suitability of IS-application in certain eco-related domains and both the evaluation of mechanisms, and the holistic approach as suggested in this article. While the theoretical work offers great contribution to the understanding of concepts and dynamics only practical implementations and their evaluation can show if IS can really contribute to user's eco-behavior change and helps to learn lessons for future implementations.

Limitations and Conclusion

This paper yields some limitations. We did not perform an extensive literature review of general psychological or social theories on behavior change and motivation. The main reasons were the complexity and broadness of these research domains. The scope in this paper is the application of theories and influencing factors in the ecological domain. Same applies for the implementation of IS-artifacts, more precisely the adoption of mechanism for eco-behavior change. In the same way, no research of practical implementation outside scientific research has been conducted, e.g. municipal sustainability initiatives. Thus, possible existing IS-based solutions might have been overlooked. We proposed a theoretical framework for the design of citizen-centric environmental sustainable information systems to build sustainable communities in smart cities. The framework considers theories and counter measures from psychological, social, environmental, and IS science to create a holistic architecture for green IS implementations. The goal is to drive further research and practical implementations in this domain.

[1] http://www.bitwalking.com/

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