

Innovative ICT Applications to Increase Social Acceptance of Transport Investments

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Abstract

Consideration of the environmental impact of transport investments is typically one of the critical aspects in the preparation phase of decisions, strongly influenced by the degree and quality of public participation. Environmental regulation often uses instruments that favour direct government intervention, while other methods based on agreements has minor attention. An overview of the environmental economics of transaction costs and exploring of the processes leading to agreements will be the basis of our work. Then, we summarise existing Information and Communication Technology (ICT) services are already available to understand and address the environmental problems. These services are usually limited to certain functions, however additional ICT solutions would increase the level of cooperation between investors and stakeholders. The aim of this research is to propose an ICT platform for facilitating agreements that improve environmental quality. We present the structure of the ICT platform, its essential features and possible implementations. Our platform may contribute to the preparation phase of several types of projects and provide an innovative tool for optimal level of pollution. Through practical examples the potential applications of the proposed ICT system in transport and urban development schemes will be shown and the estimation of achievable benefits will be given.

Keywords: environmental sustainability, social acceptance, information and communication technologies, transaction costs, transport investments.

1. Introduction

Environmental problems affect the level of aggregate welfare of the national economy and also generate unintended income redistribution within aggregate welfare by not compensating those affected by the negative externality for their losses, even though the causative agents generate additional income. Environmental protection is becoming an increasingly relevant part of the policies of both state and local governments. However, direct state intervention is still frequent to market-based solutions when it comes to implementing such policies. However, there is no general, widely applicable alternative that would replace taxes or regulations and still mitigate the environmental impact of economic activities. Most policy tools in use are based on the work of Arthur C. Pigou (Pigou, 1920), who preferred direct state intervention to internalize externalities. Public institutions often apply instruments based on the original idea of Pigouvian taxes, while other methods based on the Coase theorem (Coase, 1960) are neglected. According to the theorem, if we could find ways to help parties strike private bargains we could significantly decrease the environmental and economic damage caused by pollution and other uses of

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environmental resources. We argue that in order to achieve this, we need to establish legal and ICT infrastructures for private bargaining. The legal infrastructure determines the rights creation and distribution processes, creating the basis for negotiations.

There is a growing demand for ITS solutions to share environmental, social and economic data collected by different economic organisations or institutions. New platforms are needed to improve the quality of decision making, thus increasing trust in institutions, which is low in many countries. Our goal in this paper is to discuss the functionality an ICT system must provide to make environmental bargaining simpler and more affordable for all parties. In the first part of this paper, we describe transaction costs and the existing ICT systems aiding environmental protection and we will examine ICP platforms in the context of economic theories. In the second part, we present the general vision of the system and the most important problems our system aims to solve, then we discuss the three most important services in detail. In the last part, we provide an analysis of the system which includes an assessment of stakeholders, risks, the costs and benefits of creating the infrastructure, the expected effects on the transaction costs of bargaining and their estimate social benefits. Lastly, we will also provide some practical use cases of the environmental bargaining system. Furthermore, we need a system that can engage the population as much as possible, therefore we need all features to be easy to use, while still useful, and all information easy to understand, yet meaningful.

We have chosen the transport sector for application of the ICT system, because among its many benefits, causes social damage equivalent to 6.6% of GDP, including pollution, congestion and accidents (CE Delft, 2019). The use of space for transport causes many conflicts with local residents, our research is about a solution to reduce environmental problems and resolve conflicts. In the long term, a sustainable solution is needed to increase access to information and encourage cooperation. There is a need for social acceptance of new transport related investments, but few digital solutions for businesses interested in the transport sector. They are significant in number and have significant economic leverage and can cause high levels of externalities. It is therefore also necessary to develop digital platforms for them to strengthen their participation in the community and social cohesion. This offers not only environmental but also economic development opportunities. The environmental impact of transport development investments is typically one of the critical aspects in the preparation of investment decisions, which is strongly influenced by the degree and quality of social participation. Environmental regulation often uses instruments that favor direct government intervention, while other methods based on agreements receive little attention.

Our proposed system will not substitute the well-developed and full market solutions like EU ETS, but it can provide additional features for the future expansion of such systems, or it can be combined with other ICT systems. There is a strong demand for more simple assumptions, and it can fill a niche. Although the features are limited, a lot of possible implementations can be mentioned.

2. ICT Platforms

The ICT infrastructure establishes a common platform for environmental bargains, which we will discuss further in this article. This ICT system should provide both

information and tools that aid parties engaging in bargaining to find common solutions to their concerns. It is important to note, that there are a few factors that make such a system significantly more complex than a stock exchange. For one, the contracts resulting from these bargains are likely to be vastly more intricate than sales contracts, requiring more complicated bargaining, monitoring and enforcement procedures.

2.1 Significance of transaction costs

A primary reason for the enormous drop in transaction costs can be traced back to the fundamental nature of ICT services; In these scenarios, the development and installation costs are usually high, however, these are fixed costs, paid up-front. In contrast, the costs associated with actual system use are marginal at most, due to the system automating routine tasks previously performed by humans (World Bank Group, 2016). This has led to innovation-based growth in many areas, and we express hope that the same may be true for environmental cooperations. The ICT system should be developed and used with the involvement of the stakeholder groups having impact on the transport or tourism related projects and on the relevant environmental legislation. These stakeholders are: local governments, service providers, developers companies that develop green technologies and solutions, civilian population and organizations. The functional requirements of the ICT system will largely focus on solving the problems of individuals. Note, that most environmental negotiations involve the resolution of a negative externality, which raises the question of who is responsible for paying the costs associated with the cooperation. Usually, in these cases the Polluter Pays Principle (PPP) is applied, however, (Schmidtchen, et al., 2009) argues that attributing the costs exclusively to the polluters might cause avoidable welfare losses. Instead, they recommend resolving conflicts at the minimal possible cost, as per the Cheapest Cost Avoider Principle (CCAP). At this point in the system design, we do not aim to make a recommendation as to which principle should be used to what extent, therefore the design has to remain neutral to the actual content of the cooperations facilitated using the system.

Since our goal is to create a software system that can significantly reduce transaction costs in Coaseian bargains, we will need to understand what the factors that drive transaction costs are. The typology of transaction costs we will use are the laid out in McCann et al. (McCann 2005, page 533):

1. Research, information gathering, and analysis associated with defining the problem,
2. Enactment of enabling legislation or, alternatively, the costs of changing laws through the courts or modifying existing regulations,
3. Design and implementation of the policy,
4. Support and administration of the ongoing program,
5. Contracting costs, which are relevant when a market has been set up for a pollutant, or natural resource,
6. Monitoring/detection, or the level of compliance with the regulation, tax/subsidy scheme, or private contract,
7. Prosecution/inducement/conflict resolution costs incurred if lack of compliance is found.

The factors influencing transaction costs are identified by important determinants in some publications of Williamson. (Williamson 1975, 1985, 1991). The three major contributors

to transaction costs are: costs of search and information, bargaining costs and enforcement costs (Barbier, 2011).

2.2 Overview of the existing ICT platforms

In this section, we give a short review of the current state of ICT platforms, with focus on existing and planned computer systems that are designed to aid environmental protection. Environmental Information Systems (EIS) may accomplish one of two fundamental tasks: providing information to users and providing tools for environmental management. EIS can be divided into several categories, such as information systems and databases, analytics and visualization systems, modelling tools and decision support systems. (Denzer, 2015) Moreover, there exist applications of sensor networks technology (Lorkowski & Brinkhoff, 2015) or big data to environmental problems. There are also some platforms (Hilton, Miller, Bolger, Hetheron, & Prakash, 2015) in existence that combine several tools in order to provide aid to more complex tasks. EIS is an appropriate general framework and we have focused on the specific applications of the systems relevant to the environmental problems. If information driven technology solutions are needed use of EIS can be effective.

One of the most important database systems is called INSPIRE. (European Commission, n.d.) INSPIRE is an EU directive, seeking to establish a common infrastructure for uniform spatial information access across the EU. Spatial information is something that environmental applications (including ours) will excessively rely on. The INSPIRE directive addresses 34 spatial data themes that are divided into three annexes: In Annex I there is mostly geographical information about “places”. (Administrative units, addresses, etc.). Annex II includes geological information, land cover, and elevation, while Annex III mostly includes data on natural and artificial capital. (Buildings, species distributions, resources, etc.) As we mentioned before, INSPIRE is a relatively novel development, as it has been completed in 2021. (European Commission, n.d.)

Notably, a wide variety of ICT platforms exist that support various group decision making processes as well. While such solutions have existed for a while, they have become widespread during the COVID-19 pandemic, allowing remote work, efficient group communications, and reduce the transaction cost of meetings by conducting them online (Criado, Guevara-Gómez, & Villodre, 2020). In fact, the use of various collaboration platforms and social media for decision making has surged in recent years, including e-Government initiatives via Facebook (Alarabiat, Soares, & Estevez, 2021). Importantly, (Allen, Tamindael, Bickerton, & Cho, 2020) found that increasing citizen participation can increase the quality of urban services, which suggests that such methods may benefit other areas as well.

Still, while most of these methods are sufficient for communication and dissemination of information, they lack actual decision-making support. One notable method achieving this is Dotmocracy (Diceman, 2010). Dotmocracy is a simple solution to prioritize ideas or solutions in a large group, using special sheets to evaluate ideas. The point of dotmocracy is that people in the group would post several ideas to solve a problem independently of each other. The group would then evaluate and discuss these ideas by signaling how much they agree with the solution (dotting), while also being able to voice concerns, strengths,

weaknesses, etc. At the end of the dotting process a small number of the members use the results to formulate a common solution.

Nonetheless, currently existing environmental ICT solutions mostly restrict themselves to some form of information providing service, while providing no tools to facilitate negotiations or group decisions, as these features are mostly left to traditional methods or – in some rare cases – social media. We have summarized a number of relevant existing ICT systems.

Table 1: A summary of typical existing ICT platforms

Name	Area Covered	Features	Type
INSPIRE (https://inspire.ec.europa.eu/)	EU	Dataset aggregation Thematic dataset view	Spatial datasets
GMES (https://gmesgeoportal.rcmrd.org/)	Africa	Dataset aggregation Intuitive dataset view	Environmental spatial datasets
CEIP (https://www.ceip.at/)	Global	Dataset aggregation Analysis, reports	Aggregate emissions dataset
TEIR (https://www.oeny.hu/oeny/teir/#/)	Hungary	Dataset aggregation	Spatial datasets
OKIR (http://web.okir.hu/en/)	Hungary	Dataset aggregation “What is near me?”	Environmental spatial dataset

2.3. Modules of the proposed ICT platform

To arrive at the conceptual design of the proposed software, a universally accepted software design methodology was adopted. This method - called the Unified Process – involves first systematically collecting all the basic functionality of the proposed software. These functional elements as called use cases, as they describe a single particular scenario in which the software can be used. These use cases are represented using the Unified Modeling Language (UML) in a standardized diagram format, which collects the possible functionalities of a module, and all the actors (both users and other software elements, like databases) involved in those activities. The four core use cases are: View Area Information, Automatic Impact Evaluation, Contract Creation and Group Vote. For a more detailed economic theory background, we refer our previous work (Princz-Jakovics & Szemenyei, 2022).

The main features of the software are based on the following platform modules:

- Users can access understandable environmental information:** the most important feature in our system is the information providing functionality, since it requires no legal foundation and implementing this feature alone would be a large improvement to current conditions. The basic concept of this feature is a map based information service displaying pollution sources, natural capital, environmental quality etc. The difference from other pollution databases is attributed to several core design principles we established to aid understanding. Users can link pollution to the source with one click.

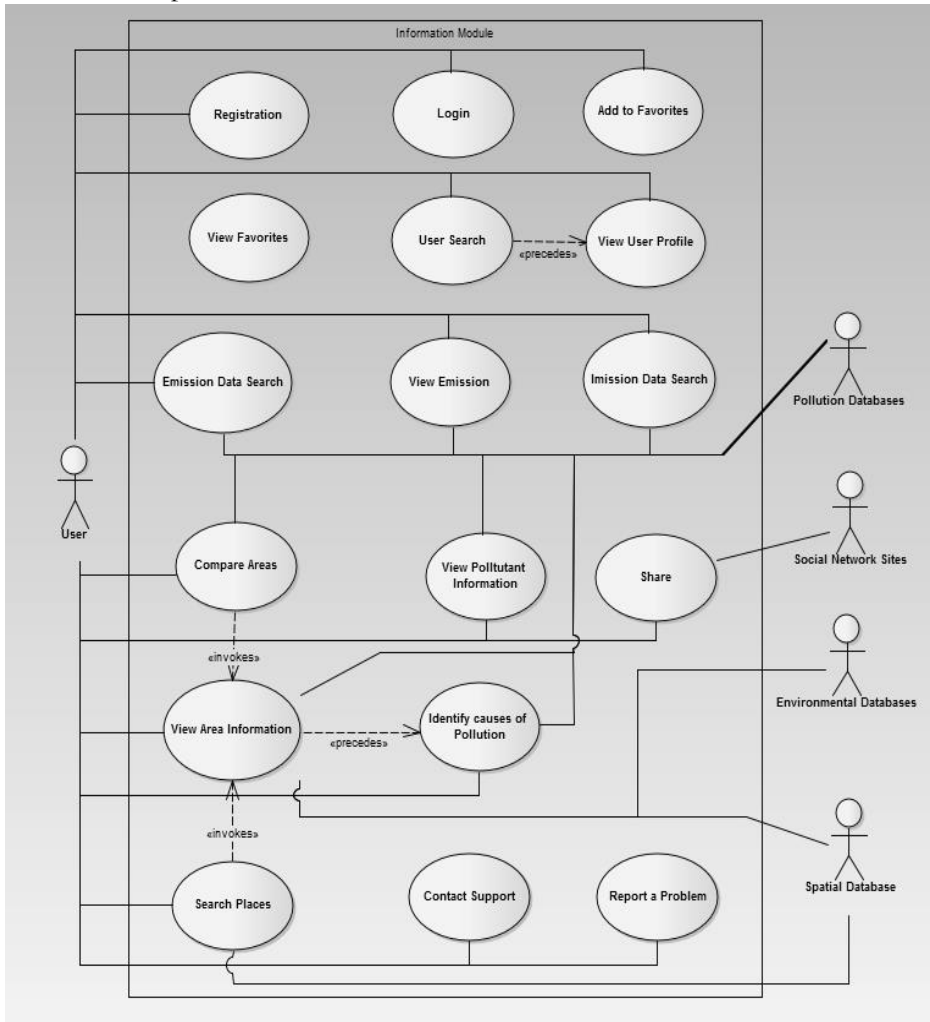


Figure 1: Functionality diagram of the Information Module

- Automatic impact assessment:** the second important feature to discuss is automatic impact assessment, which could reduce transaction costs significantly by providing powerful tools that actors could use to discover other parties affected by their economic activities. Furthermore, by making a compressed result of the

impact assessment available, we can improve the understandability of the environment's condition. It is also essential that the system would provide tools to determine the total economic and social damage of the certain effects (like health problems), since that is an excellent basis for deal-making.

- 3.) **Computer-aided contracting:** users can form groups and enter negotiations as a group and Parties can use computer-aided negotiating and contracting. Automated contracting is an essential feature to make the deal-making step significantly easier for the bargaining parties. This is a difficult task, since contracting is incredibly complex and it is hardly expected of the general population to be proficient in it. However, we think that this feature can reduce the complexity of contracting by providing support in two important areas: determining the contents of the contract (offer making) and creating it in its final form. The system will have to provide entire pre-made contracts for some of the more common scenarios, where the users would only have to fill in the case-specific details. For the less common scenarios we the software will provide contract element templates that users could use to build entire contracts. These elements could also be customized so that they would correspond to the specific parameters of the given bargaining case.
- 4.) **Users can access group decision aiding services (Community Module).** The last feature aims to solve the problem of too many parties in a negotiation by providing users the opportunity to form groups, enter negotiations as a group. In order to mitigate the problem, we also need to empower groups with powerful group decision support tools. These tools would allow individuals to evaluate an alternative (an offered contract) based on their individual preferences, and these individual scores add up to the group's evaluation of the alternative. Users could also offer new alternatives and discuss them with the group. To achieve this, an individual decision making/evaluation model needs to be implemented in the system.

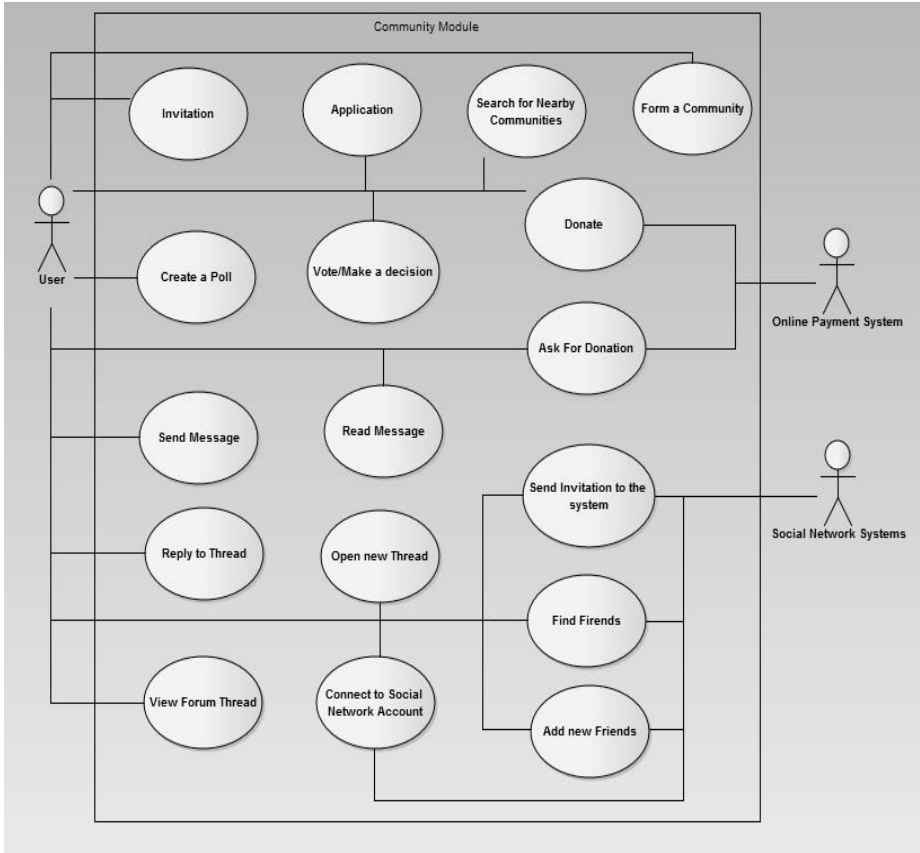


Figure 2: Functionality diagram for the Community Module

2.4. Additional features of the platform

Notably, the system can and should provide further functionalities, such as giving users the ability to access the e-Exchange system for emission permits from within the system or search environmental information about products or green technologies. However, for the sake of focus, we will only elaborate on one strikingly relevant additional feature; that is, the potential use of current state-of-the-art AI technologies in the system. In our view, modern AI solutions have to important uses for environmental cooperations: The first is automatic impact assessment. In reality, there are already several existing solutions for forecasting environmental data (Lee, Kang, & Shin, 2017; Amato, Guignard, Robert, & Kanevski, 2020) or assessing surface coverage, like vegetation (Giannetti, et al., 2018) automatically, using neural networks.

The second use case would employ Large Language Models (LLMs), like GTP-4 (OpenAI, 2023) to compress and integrate environmental information for users. In our view, the main drivers of the transaction costs of information gathering are information fragmentation (e.g. available environmental information is scattered into myriads of relatively unknown data sources), and the knowledge gap that prohibits average citizens to

understand this information, even if they took the effort to gather it. However, the first task is rather easily automated, while the second can be solved by using GPT's TL;DR functionality, which is able to accurately summarize long and complex texts into a single paragraph or a few bullet points, or even illustrative figures.

3. Applications of the proposed ICT platform in the transport sector

An instrumental part of our analysis is to present generic applications of the proposed system. The key strength of this system is the ability to support agreements between the main stakeholders: investors or developers and a large number of residents. These agreements are needed to reduce the negative environmental consequences of development projects in urban areas. We can assume that by using our ICT-based tool, all related transaction costs would be reduced. The spread of clean technologies can be facilitated if the positive effects of favouring clean technology developments can be highlighted in a transparent and relevant way in comparison with conventional solutions (Princz-Jakovics & Szemenyei, 2022). Potential areas of application include, in particular, the transport and tourism sectors, but also climate change, green energy infrastructure or waste management projects can also be supported. We argue, that in this case with the help of a well-established bargaining or co-operation infrastructure environmental organizations and private parties could have struck a deal that resulted in solutions both environmentally friendly and efficiently.

There are several more possible applications, our selected area that needs further discussion is the transport sector. This is explained by the fact that the transport sector has a particularly high level of externalities and therefore there is a strong need to reduce social damage through effective solutions. Another typical problem is that the number of parties is usually high.

3.1 Strategic background

Regulatory practice at European, national and local level should set out the objectives for promoting and adapting policies to support the carbon neutrality of the transport sector. The use of renewable energy is increasing year on year, however reducing the external costs associated with carbon emissions requires further improvements in the effectiveness of environmental regulation.

At local level, specific planning documents may be relevant for cities. Sustainable Energy and Climate Action Plans (SECAPs) summarize energy and climate issues, including transport-related interventions and development ideas at municipal level. SECAPs quantify key indicators and identify interventions and development methods that will help achieve the targets (Covenant of Mayors, 2016). Sustainable Urban Mobility Plans (SUMPs) provide long-term visions and clear implementation plans that promote balanced and integrated development of all transport modes through a participatory approach. At EU level, a new climate package is being developed, adopted by the European Parliament as "Fit for 55", which aims to reduce emissions by at least 55% in EU Member States by 2030, with a target of zero emissions from road mobility by 2035.

The proposed ICT platform should be in line with the strategic objectives detailed above and contribute to strengthening social participation. Achieving climate change objectives

requires the preparation of large-scale programmes and projects, the quality of decision-making activities can be significantly enhanced by the nature of the social participation and the changes it achieves.

3.2 Possible implementations

3.2.1 Overview of the possible implementations

The basic areas of application are found in Princz-Jakovics & Szemenyei, 2022: supporting investment projects in the preparatory phase or the transformation of existing public services by informing the affected residents about the expected environmental and other impacts of the project options. It can be assumed that if people are properly informed (including young people, who are harder to reach), they will actively participate in the preparation process of development projects, thus increasing the overall social acceptance. In the next subchapters we will present possible applications of the proposed ICT system in a selected area where the system can effectively help to solve a number of problems, namely in the transport sector. For an overview of the main areas of application in transport, the types of problems and the consequent requirements. The two main areas are information provision for the stakeholders and different kinds of mobility services.

Table 2: Overview about the possible implementations of the proposed ICT platform in the transport sector

	Area	Problem	Requirements
1	Information for the stakeholders	lack of information about pollution lack of additional functions for databases	Providing information and making automated impact assessment
2	Mobility services	conflicts between residents and service providers or operators of the public transport system	helping making agreements, deal making

3.2.2 Information for passengers

Most information systems around the world are pollution databases on national or city level. The databases used to provide information may be environmental, spatial/geological, meteorological or pollution databases. Mobility providers or infrastructure development agencies can upload their projects that require community decision making to our proposed ICT platform. As property rights are concerned with environmental issues, the involvement of different stakeholders is particularly relevant to improve the quality of decisions. It is difficult for stakeholders to gather information from different sources about a site, depending on its status (residential or work), but this can be facilitated by the proposed ICT solution.

Table 3: Tools and advantages of providing information for the stakeholders

	Area	Tasks	Advantages/ impact
1/a	Information for passengers	information about pollution of an area/or a selected location	More information in one place
1/b	Information for mobility service providers	information about clean transport alternatives	Communicate the benefits, opportunities
1/c	Information for development agencies	providing information about development projects	Overview of environmental impacts

In several cases companies or institutions should make a deal with high number of inhabitants if they would like to implement of a transport project. In an absence of information about the planned project details, possible environmental damages and positive economic consequences, such as new jobs, a massive campaign could start against the project, and it may not be implemented.

Our proposed ICT system can help making agreements between parties and use of clean technologies will be preferred and ensure that the project would not harm people's health. Users should be able to access understandable environmental information including effects. Users can link pollution to the source with one click and they can search environmental information about products, and green technologies.

3.2.3 Mobility services

There are several types of business or policy decisions in this sector of the economy that affect the environment and parts of the population significantly and such decisions could be negotiated through this system. Parties should be able to use computer-aided negotiating and contracting about use of public space, level of noise and availability of mobility services. Our methodological approach is applicable to form groups and enter negotiations as a group and to access group decision aiding services. The following examples will illustrate the possible applications of the proposed system in transport development in urban areas and the benefits that can be achieved.

Mobility services affect the level of externalities, the most important of which are noise and air pollution in urban environments. Furthermore, reducing carbon emissions is essential to mitigate the negative effects of climate change. The proposed ICT platform helps institutions or development agencies to conclude agreements with property owners or making community decision, and to adapt existing services or to install new infrastructure elements. An advantage of using the ICT platform is that users can vote on the options offered or propose new options.

Table 4: Tools and advantages of providing platform for agreements about mobility services

	Area	Tasks	Advantages/impacts Achieving deals with property owners or community decision about
2/a	use of infrastructure	expanding access restrictions to new places	where to install access restrictions, accessibility of houses
2/b	micromobility devices	installing new access points for micromobility	the further increasing of the number of mobility points
2/c	parking, use of public space	lower number of parking lots in the inner-city area, regulating parking	where parking lots would be transformed
2/d	traffic calming and pedestrian zones	new pedestrian zones and higher level of traffic calming	designation of traffic calming or pedestrian zones
2/e	stops of public transport vehicles (busses, trams etc.)	marking or relocating stops	optimal allocation of stops, accessibility to public transport system
2/f	bike and cars sharing	bike and car sharing access points	promoting sharing and electromobility
2/g	creating of congestion charging	limitation of the road traffic in inner area	system boundaries

In addition to the potential benefits, there are also limitations associated with the use of the ICT platform that also need to be explored and assessed. Time and financial resources are needed to further develop this system as a tool to improve social acceptance of transport investments. A relevant method to test its effectiveness is to set up pilot projects and evaluate the results and experiences, with a focus on the evolution of user engagement levels. This will allow their integration into decision-making processes and will require continuous follow-up and improvement to increase effectiveness.

4. Conclusion

Our goal with this paper was to present and explain a possible solution to some of the problems plaguing environmental policy: the lack of engagement of the public in protecting their own environment, partly due to insufficient and poorly presented information, partly due to the missing institutional environment that would empower them to take action. We have shown and explained how creating a software system could help us in establishing a system to aid environmental co-operation thus reducing the need for direct state intervention. We have also emphasized that the software system and the legal environment are heavily dependent, meaning that their effectiveness is greatly (though not

completely) diminished without the other. Most features of the proposed system are able to aid Coaseian bargaining and also Pigovian environmental policies as well. This is advantageous, since both set of policy tools are (and should be) actively used by governments.

While the legal and institutional frameworks are an essential part of the discussion, we argue that exploring the technological part of the proposal is just as instrumental. In order to convince policymakers to undertake the establishment of such a large-scale system, we need to present solutions to the difficulties that arise in practice. This includes providing a set of tools that assists agents in striking bargains, thus allowing free-market solutions to be used more generally, not just in special cases, such as emission trading.

There are a number of local bargains recorded, that either failed because of high transaction costs or were only struck after expensive and time-consuming litigation. Involvement of all relevant stakeholders will provide invaluable feedback for decision makers. The final decision about implementation of transport projects would be different if our software is used and all interested parties are involved into the project preparation phase.

If we suppose that the law behind the system mostly protects individuals, and that the pollution belongs to the people on whose property it is emitted, then this system would redistribute wealth, and investment between social groups and industries, and the system would also make markets more efficient. The redistribution would mostly occur from more affluent agents to poorer ones, and from pollution-heavy industries to more environmentally friendly industries. It is very hard to see, how any of these effects would hurt short or long run growth prospects. There are several possible applications, our selected area that was discussed in our paper is the transport sector.

Possible barriers to the applicability of measures are data collection difficulties, among others: several input data are required for data analysis. Of course, the estimation of emissions is only the first step, followed by the planning and implementation of reduction and offsetting measures. The carbon-neutrality target can be reached in a different emission structure, but with similar methodological steps. Achieving socially beneficial co-operation in the form of voluntary agreements with the municipalities or other kind of planning contracts, which is already in current practice, poses a number of technical difficulties, but the development of ICT infrastructure as a supporting framework promises similar or even more positive results.

Comparison of the results of this research with current studies shows that the ICT platform effectively allows the linking of the differently targeted environmental, spatial or investment related databases and provide proper integration of the different features: access to understandable environmental information, automatic impact assessment, computer-aided contracting and community module. There are specific platforms that offer features, specialised in the provision of a particular type of information, but these systems presented in the relevant literature do not capture the full spectrum of services that can help to reduce transaction costs.

In conclusion, we argue that our platform can provide an innovative tool for private environmental co-operations, and may contribute to the preparation phase of several projects. We believe, that by providing a modern ICT-based solution, transaction costs of bargaining can be significantly reduced, while at the same time our platform might be

successful of increasing the engagement of younger generations. Overall, the use of innovative information technologies can largely aid in achieving optimal environmental policy decisions at significantly reduced cost.

Our proposal poses several intriguing questions requiring further research. This includes a detailed analysis of the costs and benefits of establishing this system, as well as the exploration of the legal and institutional environment required for our system to achieve maximal effectiveness. There is also the interesting problem of environmental impact assessment aided by modern machine learning and artificial intelligence methods.

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