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Foresight as a Tool for the Planning and Implementation of Visions for Smart City Development

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Abstract: Global change, including population growth, economic development and climate change constitute urgent challenges for the smart cities of the 21st century. Cities need to effectively manage their development and meet challenges that have a significant impact on their economic activity, as well as health and quality of life for their citizens. In the context of continuous change, city decision-makers are constantly looking for new smart tools to tackle it. This article addresses this gap, indicating foresight as an effective tool that anticipates the future of a smart city. Its aim is to develop a methodology for planning and implementing a vision of smart city development based on foresight research. The proposed methodology consists of five stages and was developed with the use of methodology for designing hybrid systems. It is an organised, transparent and flexible process which can facilitate the development of sustainable and smart future visions of smart city development by virtue of the involvement, knowledge and experience of a large number of urban stakeholders at all stages of its creation. The article discusses in detail the operationalisation of each stage of the methodology in which the following main methods were used: megatrend analysis, factors analysis: social (S), technological (T), economic (E), ecological (E), political (P), relating to values (V) and legal (L) (STEEPVL), structural analysis, Delphi, creative visioning, scenarios and identifying actions related to the development of a smart city, divided into four categories: new, so far not undertaken (N); implemented so far, to be continued (C); redundant, to be discontinued (R); actions that have been implemented in the past and to be restored (R) (NCRR). The summary enumerates the benefits that foresight implementation can bring to the smart city.

Keywords: smart city; foresight; sustainable development; strategic planning; vision; co-creation

1. Introduction

Together with a growing popularity of the smart city concept, there appear numerous new projects based on innovative technologies helping cities to solve the emerging problems of technical infrastructure [1,2], pollution and environmental protection [3,4], waste management [5,6], spatial development [7,8], logistics and urban transport [9,10], ageing society [11,12], poverty [13,14] and low levels of involvement of residents in public affairs [15,16]. After all, many of them fail to satisfy their initial objectives due to the fact that they are not adapted to the complexity, diversity and uncertainty characterising contemporary cities [17]. They are excessively focused on investing in advanced technologies, often without real recognition of the problems in cities and without the involvement of the local community in city co-management [18–21]. A smart city should ultimately aim to become a creative, sustainable area, providing a high standard of living, a friendly environment and broad economic development prospects [22]. Cities can be defined as smart if they include the following elements: smart economy, smart mobility, smart environment, smart people, smart living and smart governance [23,24]. The literature, however, provides a number of definitions that are mainly focused on the technological aspect [25–30]. It should be noted that only by taking due account of other areas and their mutual relations will smart cities be able to achieve effective implementation and long term success [31,32].

A city cannot be considered smart if it is based solely on technology [33]. The holistic approach of a smart city focuses on people and their needs, and technology plays a supporting role. Its most important aspect involves determining whether new technologies constitute better solutions to problems related to city development than previously available technologies [34]. The needs and preferences of citizens, social interactions and cooperation should be at the heart of designing smart solutions for cities. Technical solutions and infrastructure should serve the interests of the people who live and work there. A modern city is based on the citizen and his or her specific characteristics and abilities [35,36]. The success of a smart city is largely based on the adoption and use of smart solutions by citizens, supporting decision-making and encouraging behavioural change [37]. Its residents will be the end users of these solutions, hence they must have a clear positive impact on their daily life [38]. In the new generation of cities ('Smart City 2.0'), infrastructure and technologies are no longer the focus of development. It is the wisdom of citizens, visitors and businesses in interconnected ecosystems that engage in social inclusion activities that play a significant role [39]. A city is smart when it is managed in a smart, efficient and sustainable way [40].

Through this perspective, the distinguishing features of future cities should be the following [41–44]:

- Sustainable development—through the achievement of social and economic stability, effective, multifaceted management of the urban environment;
- Orientation towards citizens—planning should be focused on the needs of citizens, including elements such as life satisfaction, physical and mental health, level of independence, education, social relations, and cultural diversity;
- Effectiveness, attractiveness, and dynamics—these are necessary to attract investment and stimulate entrepreneurship;
- Accessibility—to enable local communities to participate in all aspects of city life;
- Resilience to crises and shocks, flexibility and competitiveness—the city should have the potential to adapt to changing social, economic and cultural conditions;
- Good governance—the city should make optimal use of its resources in order to effectively implement short and long-term development programmes;
- Responsiveness—it should have a rationally developed digital infrastructure to respond to emerging problems and make appropriate decisions in real time;
- Future-oriented—through appropriate city resource planning and management.

Therefore, decision-makers are challenged with a search for new, often unconventional tools that enable effective management of the sustainable development of a smart city and provide an opportunity to avoid threats resulting from an increasing complexity and uncertainty of the environment. According to the literature review, the development of new smart city solutions involves a growing use of tools that involve many stakeholders, including end users, in working together to create mutual and shared benefits [45,46].

Foresight may provide an answer to the existing need to create a vision for the development of a smart city which will enable sustainable development. Among many definitions of foresight, the best-known ones were those proposed by Martin and Georghiou [47]. According to Martin, foresight is a process involved in systematic attempts to envisage the long-term future of science, technology, economy and society. This process aims to identify strategic areas of science and technology that should provide maximum economic and social benefits [48]. Georghiou, on the other hand, presents foresight as a systematic way to assess the development of science and technology, which can clearly affect industrial competitiveness, generating wealth and boosting quality of life [49].

Foresights were first applied by the U.S. Army during World War II in order to enhance preparations for the "unpredictable" moves of the enemy [50]. However, since the second half of the 1960s, foresight methods have been used and improved to predict the development of technology in large industrial corporations in the United States, including the energy sector [47]. As a result of its observed range of benefits, foresight was also used at the national level in the public sector. It was recognized as a process enabling the construction of development strategies, addressing global challenges and shaping the long-term policies of many large and small countries, e.g., the USA, Japan, Great Britain, Germany, France, Austria, Poland, Hungary, the Czech Republic, Ukraine, Spain, Mexico and Peru [49–52]. At present, it is gaining popularity at the regional [50,51] as well as urban level, in such countries as the USA [53], Great Britain [54], Spain [55], Poland [56]. Despite a number of benefits that arise from the use of foresight in relation to the development of a country, region or cities, thus far no foresight project focused on smart city development has been initiated.

Smart city foresight can be defined as a systematic process based on the participation of a wide range of stakeholders. It is a process that co-creates coherent visions of the city in order to effectively manage future long-term changes and create opportunities for sustainable development of the city in the following aspects: economy, mobility, environment, people, living and governance.

Among the advantages of using this tool, the following deserve special consideration:

- It allows us to build a long-term development perspective for the smart city;
- It enables the detection of problems related to contemporary challenges of the smart city before they appear, and enables us to take preventive measures;
- It allows for an assessment of the consequences of current actions and decisions taken in the smart city;
- It enables a broadly understood creation of a smart city, anticipating the future and making the most effective solutions;
- It involves a large number of stakeholders in the development of the smart city, by means of which it will support the development of a vision of the future and development priorities that can be implemented;
- It creates an open ground for discussing the future of smart city development and allows a consensus to be reached in cases of divergent opinions and expectations among stakeholders;
- Due to the application of various research methods, it enables the confrontation of views of many stakeholders of smart city development;
- It strives to establish cooperation between stakeholders and arouses their sense of responsibility for the implementation of the results achieved.

In connection with the above-mentioned reasons for using foresight in the smart city concept, the article incorporates the author's research methodology.

Its aim is to develop a methodology for planning and implementation of a vision of smart city development based on foresight research. Foresight is intended be an organised, transparent and flexible process, which will facilitate the development of sustainable and intelligent future visions for the development of a smart city by means of engagement, knowledge and experience of a wide range of urban stakeholders at all stages of its development. Ultimately, all stakeholders will be able to understand and use it efficiently and subsequently implement its results.

The article has the following structure. Section 2 presents issues related to foresight—its definitions and evolution, as well as methods used in the research process. Section 3 describes the methodology of designing hybrid systems used to develop the methodology of planning and implementation of the vision of smart city development. Section 4 is dedicated to detailed characteristics of the developed methodology of planning and implementation of the vision of smart city development. Section 5 presents conclusions on the benefits of using foresight research in planning smart city development, and enumerates the limitations of the research, as well as directions for future scientific work.

2. Materials

2.1. Fundamentals of Foresight

In 1985, Coates made an attempt to define foresight and described it as a process offering a full understanding of the forces shaping the distant future, which should be taken into account in formulating policy, planning and decision making. This process monitors signals of emerging trends that have considerable implications for the policy. This makes the implementation of policies more appropriate, flexible and effective in the context of time and changing operating conditions [57].

Miles defines it as an equivalent of a stream of systematic efforts aimed at looking towards the future and making the most effective choices. However, foresight assumes that there is no single future. Depending on the present-day action or lack of action, many variants of the future are possible, but only one of them will come into existence [58]. Saritas and Loveridge point to the need to involve new stakeholder groups in research, going beyond traditional research area experts [59]. According to the definition containing an element of social anticipation of future changes (created within the Foresight for Regional Development Network (FOREN) project), foresight is systematic, participatory, focused on gathering knowledge about the future, a process of building a medium-term and long-term vision, oriented on today's decisions and mobilising joint activities [60,61]. In the context of this definition, five main elements of foresight were also identified: anticipation and future design, participation, social networks, strategic vision and current decisions, as well as action [61]. Cassingena Harper also attaches great importance to participation and consensus-building. This distinguishes foresight from other future-oriented approaches. The foresight process is based on intensive iterative periods of open reflection, networking, consultation and discussion, which are necessary to create to a common vision for the future and a sense of ownership of the developed strategy. It discovers common space for open thinking about the future and the incubation of the strategy [47]. Anderson expresses a similar view, pointing out that foresight involves shaping the future through concerted actions of self-sustaining networks of interested groups [62].

Foresight is a set of tools that facilitate the construction of scenarios for development over a relatively long period of time (usually 10–30 years), as well as in cases of development that are difficult to predict [63]. It is an attempt to collectively anticipate important factors as well as threats that may affect the future of society [64]. Foresight should not be dominated by science and technology alone—socio-economic factors also play an important role here, having a significant impact on innovation, wealth creation and quality of life [47–49,65,66]. It is a deliberately structured process that combines the expectations of different actors in order to formulate strategies for the future [66]. It fosters a dialogue between process participants and provides a framework for communication and sharing opinions on possible future scenarios [67]. It establishes a language of social debate and creates a culture that involves society's considerations towards the future [50]. In the course of preparation and implementation of foresight projects, entrepreneurs, scientists, representatives of public administration, non-governmental and social organisations, as well as politicians, participate in the conducted analyses and evaluations. These participants directly deal with science, as well the as economy and its regulations, thus ensuring a substantively accurate description of problems and indicating the possibilities of solving them. Foresight should be carried out through iterative, gradual and even experimental tasks as a result of which stakeholders will become more aware of future opportunities and, at the same time, commit themselves to take actions that reflect their better understanding [68].

In summary, the foresight process can be synthetically characterised by means of a description proposed by Martin, referred to as '5K' [69]:

- Communication—a platform enabling communication between partners involved in the process as well as the flow of information between organisers and the public concerned by the results of the undertaken initiative;

- Focus on the long-term perspective—focusing on the development of the future and thinking systematically about long-term processes;
- Coordination—partnership-based management of the knowledge generated by the project, as well as at the organisational level, managing activities within the implemented process;
- Consensus—reaching an agreement in cases of diverging opinions and expectations among the participants of the process which may result from a loss of compatibility of objectives or visions for the development of the research area, as well as in the context of the obtained results requiring implementation after completion;
- Consistency—systematic involvement of stakeholders in the long-term process in order to generate expertise necessary for executing different stages of the process, while eliminating problems associated with obstacles to participation in the initiative related to the performance of professional duties.

A typical downside of foresight and future studies is a disconnection or mismatch between the outcome of the process and its application in the studied area (country, region, industry, company). There is a 'linear' (1.0) model of foresight within a deterministic frame. An 'evolutionary' (2.0) model of foresight is more focused on adaptive innovation. In contrast, there is a 'co-evolutionary' 3.0 model of synergistic foresight: focused on co-learning, co-creation and co-intelligence, not only within the foresight programme but also across a wider city and its economies, governances and technologies [18]. The term 'synergistic' can be ascribed to science and art, understanding and working in synergy, which literally means 'working together' [70]. Synergies exist between people, organisations, communities, economies, political systems, technological systems. Synergistic foresight focuses on synergic features in four main dimensions—subject, process, agenda, and object.

Synergistic foresight presents a more open, multifaceted, interconnected and co-intelligent way of working with many fields, with equal priorities for social, technical, political or cultural areas, worldviews and systems of values. At the same time, the process itself is based on a practical, gradual method of research and deliberation, adapted to the challenge of cognitive complexity. For this purpose, synergistic foresight operates in the '4S' cycle, at four main stages. In the co-evolutionary process, each of the four stages involves placing a stress on the principles of synergistic co-intelligence. The 'system mapping' stage focuses on collaborative 'co-learning'. The 'scenario mapping' stage induces collaborative thinking (i.e., 'co-thinking') to look beyond immediate trends, towards bigger pictures of change and uncertainty. The third stage, 'synergy mapping', focuses on co-creation and co-innovation for system transformation. Lastly, the fourth stage of 'strategy/road-mapping' reflects on the implications for action in co-production that leads towards co-intelligence [71]. Ravetz and Miles point out that the 3.0 model is not 'better' or more advanced than the 1.0–2.0 type foresight. The 3.0 model may be suited to different kinds of problems, less linear and bounded as well as more co-evolutionary and transformational. The 3.0 model does not replace 1.0–2.0 versions, but it can work better as a parallel and complementary layer [71].

In the context of city development, foresight focuses on the need to create a coherent vision of the city in order to plan and manage future long-term changes and create opportunities for new investments in the local urban economy [72]. The foresight project at the city level was launched in the 1980s in the Singapore City-State [73] and next in Atlanta in the USA [53], Birmingham, Bristol, Cambridge, Lancaster, Liverpool, Manchester, Milton Keynes, Newcastle, Reading, Rochdale in United Kingdom [54,72], Spain [55], Konin, Lublin, Wrocław in Poland [56,74,75], Rustavi in Georgia [76], Bulungan in Borneo [7].

These projects so far have involved attempts to combine research on the future, urban research and ecological thinking with parallel analyses of complex systems and innovations as well as technology assessment [71]. Urban foresight mainly focuses on creating a coherent vision of the city to plan and manage future long-term changes [7,53,54,56,72,74–76]. Foresight, in relation to cities, has as well been applied in such specific research areas as urban spatial planning [55], demographic change [77], climate change and energy innovations [78,79] as well as ageing society [80].

Unfortunately, an overview of foresight projects conducted in cities reveals that so far none of them has launched such a project focused on smart city development and its elements: economy, mobility, environment, people, living, governance. Cities striving for smart development, apart from the implementation of technological solutions, need strategies that will make it possible, among other things, to socialise the vision of development or to identify trends affecting its activity as well as social and economic conditions. These visions can be successfully designed with the use of foresight, which allows for identifying changes in the micro- and macro-environment, interpreting their impact on the city and formulating visions and solutions that will ensure the long-term development of a smart city. This approach is in line with the latest trends in research, which diverges from the traditional perception of foresight as a set of research methods and techniques focused on detecting changes in the environment, and shifts towards socialisation, focusing on co-learning, co-creation and co-intelligence.

2.2. Methods Used in Foresight Research

Foresight is implemented with the use of a variety of methods, both strictly scientific and heuristic, based on expert intuition [81]. The catalogue of methods used in foresight research is wide and diversified, and due to the continuous development of foresight, is still open [47,82]. Nazarko claims that research instruments are systemic, analytical, algorithmic, heuristic, quantitative and qualitative methods [82].

Popper [81] made the most popular method classification in the literature and Magruk [82] prepared the most comprehensive and multifaceted typology. According to foresight practitioners, the classification proposed by Popper is called 'a foresight methodological diamond'. It is composed of four dimensions [83,84]:

- Creativity—methods using a combination of original thinking with creative invention (e.g., Wild Cards, Scenarios, Brainstorming, strengths, weaknesses, opportunities, and threats (SWOT) analysis);
- Expert knowledge—methods using the skills and knowledge of experts in a given field (e.g., Expert Panel, Key Technologies, Multi-Criteria Analysis, Impact Analysis);
- Interaction—methods based on creating new knowledge and building a vision for development with the involvement of a wide range of stakeholders (e.g., Surveys, Conferences, Workshops, Citizen Panels, Stakeholder Analysis);
- Facts—methods supporting the understanding of the current state of the research area (e.g., Literature Reviews, Weak Signals, Scanning, Bibliometrics).

Quantitative methods use numerical parameters which characterise a studied phenomenon or research object. Qualitative methods are used to describe complex and difficult to quantify phenomena. The use of indirect methods makes it possible to present complex phenomena based on numerical data [82]. According to Popper, in order to design an effective research methodology, methods should be selected from each tip of the foresight methodical diamond [51].

Magruk noted that classifications often do not take into account many foresight research methods and cover only a few groups, which are based on general characteristics. Therefore, he developed a classification based on phenetic analysis, which makes it possible to indicate a common semantic plane for methods belonging to a given group and based on a similar research workshop. This type of classification, based on clusters, makes it possible to clearly identify the characteristics of individual groups, which should be considered in the process of formulating research methodology [85]. Table 1 presents classification developed by Magruk. Based on the analysis of descriptions of urban foresight projects available in the literature and the author's research experience in the implementation of foresight projects, Table 1 indicates methods that can be useful in smart city foresight.

Table 1. Classification of foresight research methods with indications towards methods useful in foresight smart city based on [85].

Classes	Methods
Consultative	**Voting**, Polling, **Survey**, **Interviews**, Expert Panels, **Essays**, **Conferences**, **Workshops**, **Citizen Panels**, **Brainstorming**
Creative	**Wild Cards**, **Weak Signals**, Mind Mapping, Lateral Thinking, Futures Wheel, Role Play, Business Wargaming, Synectics, Speculative Writing, **Visualization**, Metaphors, Assumption Reversal
Prescriptive	**Relevance Trees**, Morphological Analysis, Rich Pictures, Divergence Mapping, Coates and Jarratt, Future Mapping, **Backcasting**, SRI Matrix, Science Fiction Analysis, In-casting, Genius Forecasting, Futures Biographies, TRIZ, Future History, Alternative History, **Creative Visioning**
Multi-criterial	**Key Technologies**, Source Data Analysis, Migration Anal., Shift-Share Anal., DEA, **Factor Anal.**, Correspondence Anal., Cluster Anal., Sensitivity Anal., AHP, Input-Output Anal., Prioritization, SMART, PRIME, MCDM
Radar	Scientometrics, Webometrics, Patent Analysis, **Bibliometrics**, Technological Substitution, S-Curve Anal., **Technology Mapping**, Analogies
Simulation	Probability Trees, **Trend Extrapolation**, Long Wave Anal., Indicators, Stochastic Forecast, Classification Trees, **Modelling and Simulation**, System Dynamics, Agent Modelling
Diagnostic	Object Simulation, Force Field Anal., Word Diamond, **SWOT**, **STEEPVL**, Institutional Anal., DEGEST, Trial and Error, Requirement Anal., Theory of Constraint, Issue Management, ANKOT
Analytical	SOFI, **Stakeholder Anal.**, **Cross-Impact Anal.**, **Trend Impact Anal.**, **Structural Anal.**, **Megatrend Anal.**, Critical Influence Anal., Tech. Barometer, Cost-Benefit Anal., Technology Scouting, Technology Watch, Sustainability Anal., **Environmental Scanning**, Content Analysis, FMEA, Risk Anal., Benchmarking
Overview	**Web Research**, **Desk Research**, **Technology Assessment**, **Social Network Anal.**, **Literature Review**, Retrospective Analysis, Macrohistory, Back-View Mirror Analysis
Strategic	**Technology Roadmapping**, Technology Positioning, **Delphi**, **Scenarios**, **Social Impact Assessment**, RPM, Technological Scanning, Multiple Perspectives Assessment, Causal Layered Analysis, MANOA, Action Learning, **NCRR**

Legend: **Bold** represents methods useful in smart city foresight.

3. Methods

Foresight is a process where its course should be adapted to the conditions of the research area and resources intended for the implementation of this type of research. So far, no uniform or universal research methodology for foresight has been developed. Any attempt to develop a universal methodology should rather be a sort of inspiration for researchers, not a rigid research procedure. Popper indicates that methods should be chosen flexibly and made to correspond with the purpose of the planned foresight research [86].

According to Alexandrova et al., the choice of research methods should be determined primarily by the purpose of the research, available funds, duration and time horizon of the research, economic and social context, involvement and number of experts and stakeholders, possibility of creating links with other methods and competence of managers [87]. Popper indicates that, on average, six methods are used in foresight research [88].

The selection of research methods was initially determined by three phases of foresight indicated by Martin and Irvine, i.e., pre-foresight, foresight and post-foresight [89]. Voros, based on Horton's division (phases: collection, interpretation, evaluation), made modifications, extracting four phases of foresight: input, foresight, output and strategy [90]. Miles supplemented the proposed approaches with a re-edition phase, distinguishing five phases of foresight: pre-foresight, recruitment, generation, action and re-edition [87]. Along with the development of foresight research, Bishop, Hines and Collins proposed another modification, taking into account six phases of foresight: construction, scanning, forecasting, vision building, planning and action, but this approach failed to take into account the re-edition phase indicated by Miles [91]. Magruk provided another addition, indicating seven stages: initial, scanning, recruitment, main, planning, action, resumption [92]. Lastly, Nazarko added the evaluation phase to the process. In his synthetic approach, Nazarko distinguished eight research phases of the foresight process: initial, scanning, recruitment, knowledge generation, anticipation, action, evaluation and resumption [82].

In order to develop a methodology for planning and implementing the vision of smart city development, a hybrid systems design methodology was used. According to Magruk, the hybrid systems design methodology should involve four stages [92]:

- Identifying factors influencing foresight research methodology;
- Selecting foresight research methods in line with the classification, research context and stages of the foresight process;
- Selecting methodological hybrids;
- Constructing a hybrid system.

The first stage involves the identification of factors influencing research methodology. The factors that play a key role in the selection of appropriate research methods are: access to quantitative and qualitative data, methodological competence, key attributes of the methods, relevance of the combination with other methods and cognitive nature [93].

At the second stage of designing the hybrid research methodology, foresight methods are selected according to the classification, research context and stages of the foresight process. Table 1 includes 116 methods, divided into 10 classes (Figure 1). It also illustrates the strength of connecting 10 classes of methods with eight phases of foresight research, simultaneously assigned to four research contexts: cognitive, social, technological and economic [82].

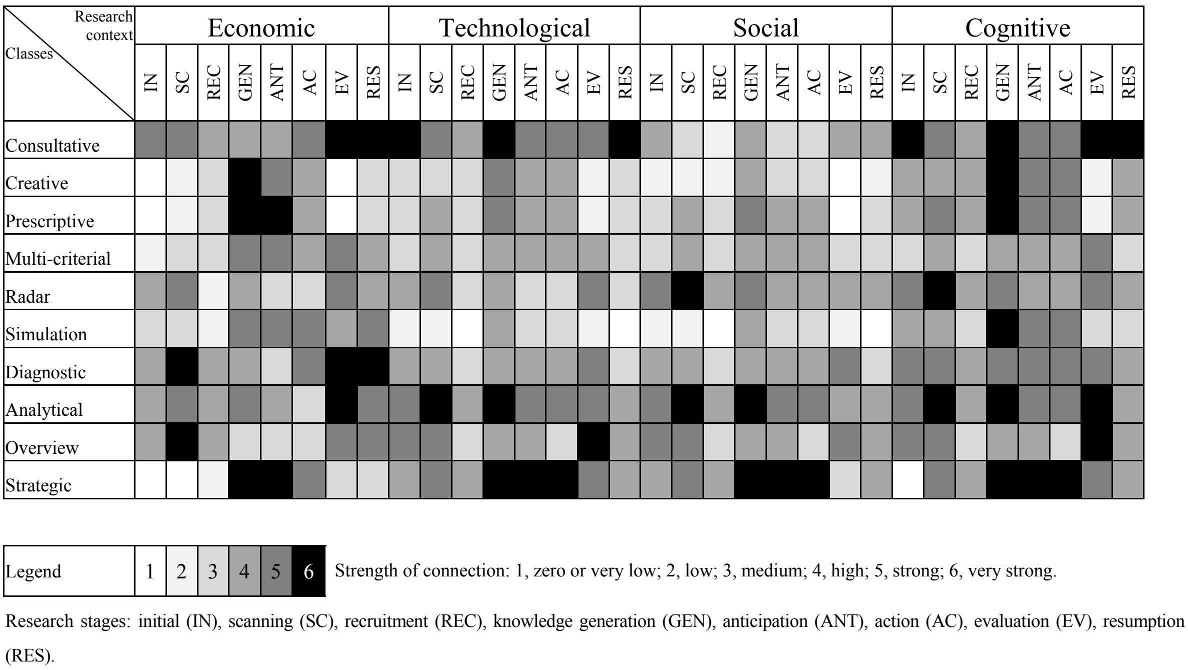

Figure 1. The strength of connecting a given class of methods at particular stages in the foresight process, in the context of the economic, social, technological and cognitive aspects [82].

The selection of the research context and the choice of methods are strongly interdependent and directly related to the individual stages of foresight research. Each class forms groups of methods that are mutually substitutable and complementary to those in other classes. Methods from only one class should not be used. Such an approach may cause an undesirable effect, in which methods based on similar information resources will generate results in a similar way. Such a situation will make it impossible to obtain the synergistic effect [92]. Proper methodology will be ensured by selecting methods from different classes in each phase. At the same time, it is important to provide a strong reference to all research contexts. Putting too weak an emphasis on all contexts or placing too strong a stress on one of them may lead to the undesirable dominance of a specific domain [82,92].

The third stage should focus on the selection of methodical hybrids. Magruk distinguishes hybrids with the following structures:

- Sequential—output values from one method become input values in the next method. It is used when the results of a method from one stage of foresight constitute input to the next stage;
- Loosely related—information is exchanged between individual methods, even though each method works separately;
- Nested—a high degree of integration. There is a frequent interweaving and exchange of information between the applied methods (multiple feedbacks). This structure allows for major and auxiliary methods. Information flow takes place in both directions;
- Supporting—they are characterised by a clear division into basic and supporting methods. An auxiliary method (not always active) may use the same input as the basic method. However, the results of the auxiliary method must be processed by means of the main method [92].

The fourth design stage leads to the development of a final hybrid system, where appropriately selected methods can achieve a synergistic effect [92].

4. Results

4.1. Methodology of Planning and Implementation of the Vision of Smart City Development

The methodology of planning and implementation of the vision of smart city development was construed with regard to three key areas: stages of foresight process, research context and classification of methods. The developed methodology ensures a balance between referring to the four contexts. The methods used belong to six different classes and refer to different contexts, thus they remain complementary. The methodology uses three types of hybrids: sequential, nested and supporting.

For the needs of the methodology for the planning and implementation of a vision of smart city development (Figure 2), 15 methods belonging to six different classes were chosen. These methods were selected in such a way as to maintain a balance between references to contexts (economic, technological, social and cognitive) related to the research area—the city and its individual aspects, and eight phases of foresight. The cognitive context is linked to desk research, web research, Delphi, survey and conference. The social context was expressed by megatrend analysis, citizen panels, brainstorming, workshops, conference and voting. The technological context refers to megatrend analysis, structural analysis, creative visioning and identifying actions related to the development of a smart city, divided into four categories: new, so far not undertaken (N); implemented so far, to be continued (C); redundant, to be discontinued (R); actions that have been implemented in the past and to be restored (R) (NCRR) [94], and the economic context refers to the factors analysis: social (S), technological (T), economic (E), ecological (E), political (P), relating to values (V) and legal (L) (STEEPVL) [95], scenarios and the NCRR.

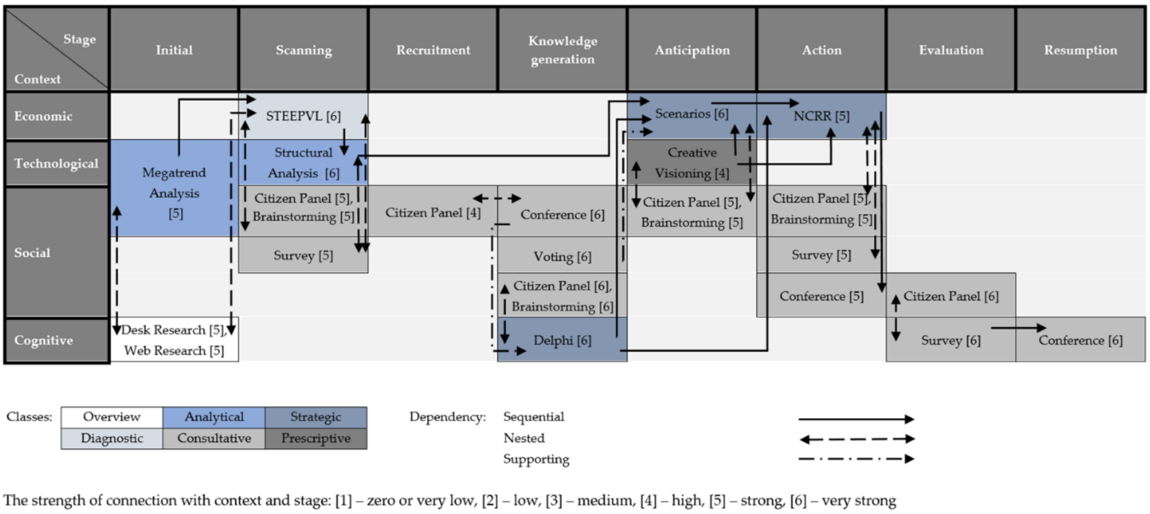

Figure 2. Methodology of planning and implementation of the vision of smart city development.

The methods from the consultative class are applied in seven out of eight foresight phases and relate mainly to the social context. Particular emphasis was placed on methods from the consulting class due to the fact that one of the key elements of foresight is social participation, and methods from this class require the involvement of a wide range of stakeholders from the research area. The methodology also includes three methods from the strategic class, two from the overview and analytical class and one from the creative and diagnostic class. Each of the methods indicated a high, strong or very strong strength of connection with particular phases of the foresight process.

Megatrend analysis carried out on the basis of desk and web research allows us to gather necessary theoretical knowledge about the conditions of smart city development (initial phase). Within the framework of sequential hybrids, megatrend analysis provides an input to the work of a citizen panel (scanning phase) in the form of the STEEPVL analysis. The STEEPVL analysis within a sequential hybrid with structural analysis allows for the indication of key factors of smart city development. These analyses are a primary tool that facilitates the identification of driving forces of smart city development scenarios. Another method is Delphi. Respondents of the Delphi survey, city stakeholders, are identified in the course of the work of the citizen panel (recruitment phase). The Delphi method (knowledge generation phase) within the sequential hybrid provides input to the scenario method (anticipation phase) and the NCRR method (action phase). The creative visioning method is part of another sequential hybrid, providing information for both scenario and NCRR methods. The scenario method, by indicating assumptions and conditions for building the vision of the future, then provides input to the NCRR method. The analysis is concluded by a conference dedicated to presenting research results to a large number of smart city stakeholders. Feedback received during the conference, if necessary, can be taken into account as part of the supplementation/correction of the results obtained from the NCRR method. The last two phases of the process—evaluation and resumption—should be initiated at a certain interval to examine the effectiveness and efficiency of the implementation of research results, and subsequently to resume the process. The sequential hybrid is based on an evaluation survey, providing input to be presented at the conference. The aim of the conference is to take measures that resume the foresight research process that will contribute to the development of an updated vision of a smart city.

Within the framework of nested, highly integrated hybrids exist interweaving and exchanges of information between the citizen panel and survey research methods. In this structure, there are also relations in which desk research, web research, citizen panels, brainstorming and survey research act as auxiliary methods to megatrend analysis, STEEPVL analysis, Delphi method, scenario method, creative visioning and NCRR method.

The methodology also uses a supporting hybrid based on basic and auxiliary methods. The supporting method, i.e., voting (which is not always active), supports structural analysis and the scenario method when structural analysis fails to provide information about the two driving forces of smart city development scenarios.

4.2. Operationalisation of the Methodology for Planning and Implementation of the Vision of Smart City Development

Structural and methodological complexity necessitates the operationalisation of the research methodology aimed at improved planning of different stages of the research process. The proposed methodology of planning and implementation of the vision of smart city development leads to the development of a general research scheme (Figure 3). Five main research stages were distinguished in this process:

- Stage 1: initiation, megatrend analysis, STEEPVL, structural analysis;
- Stage 2: Delphi;
- Stage 3: scenarios—creative visioning;
- Stage 4: NCRR;
- Stage 5: evaluation and resumption.

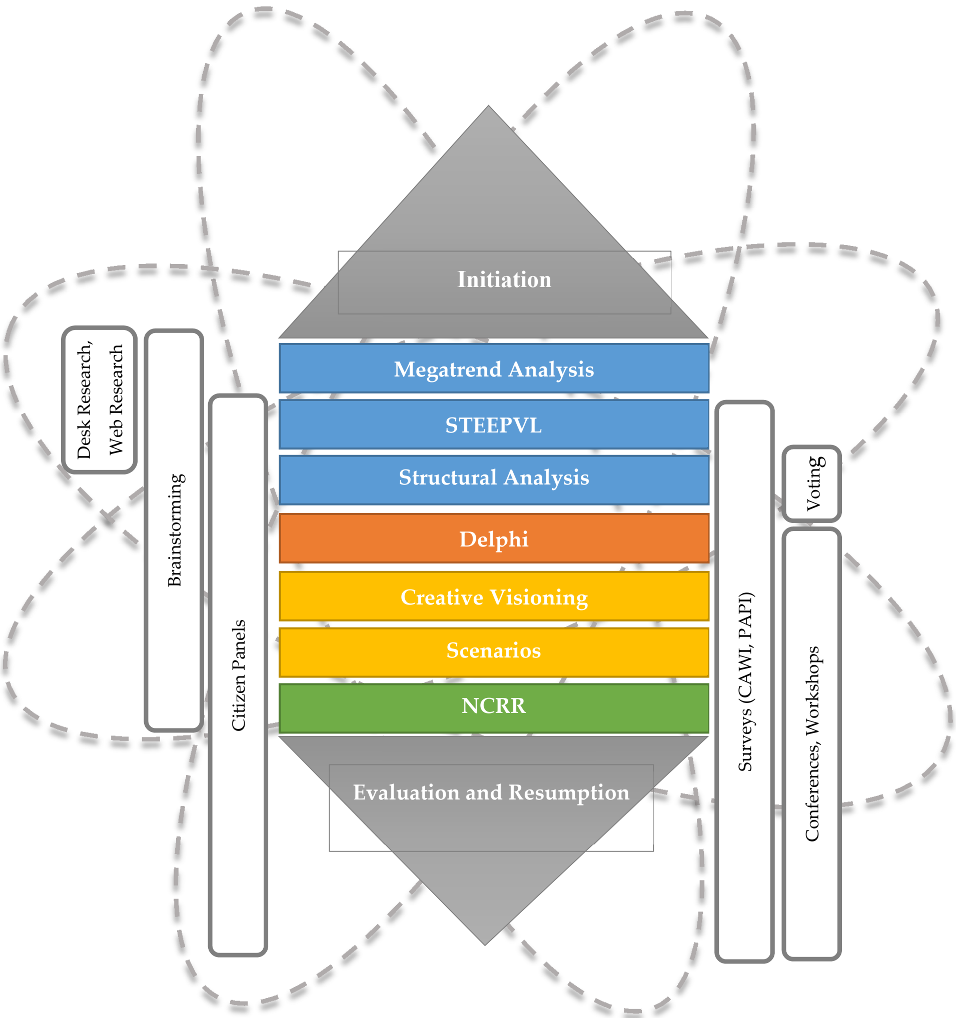

Figure 3. General scheme of methodology for planning and implementation of the vision of smart city development.

In the individual sequences of the research process, methods closely related to social participation, which are an indispensable element of foresight research, were nested. These methods include desk research, web research, citizen panels, brainstorming, surveys, workshops and conferences. Additionally, voting was indicated as an optional method to be used in the case of such a need.

The research process should be initiated by a team consisting of the representatives of city authorities, business and science sectors, NGOs (non-governmental organizations) and the media. It should engage a foresight expert as an advisory body who should supervise the correctness of the process and assist in methodological issues. The team's composition should remain unchanged at all stages of the research process.

In the course of preliminary works, the team should form a group of stakeholders in the city's development, constantly participating in the works of the citizen panel. It should be composed of the representatives of city administration, business (companies differentiated by type of activity), science, field specialists (e.g., spatial planning, infrastructure, environmental protection, energy, transport, social policy, etc.), NGOs, the media and residents belonging to different age groups (youths, students, adults, seniors). The group should be diversified in terms of the represented professional sphere, education, gender and age.

The size and structure of the implementation team and stakeholder groups should be adapted to the specific conditions of each city (depending on, e.g., city size, human capital, etc.).

Figure 4 illustrates the operationalisation scheme of the Stage 1 of the research process. Six research steps are presented in relation to nine research methods: megatrend analysis, desk research, web research, STEEPVL analysis, structural analysis, civic panel, brainstorming and survey research.

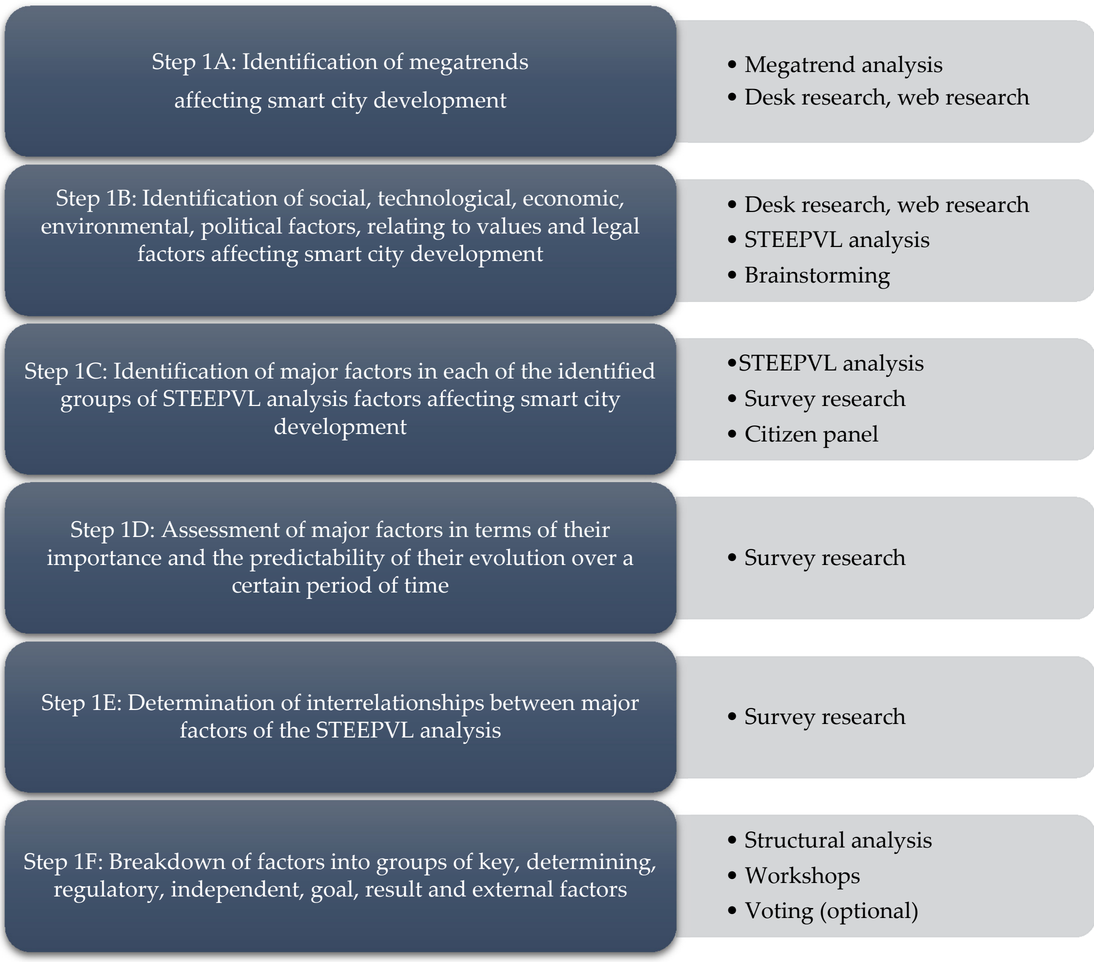

Figure 4. Operationalisation scheme for Stage 1 of the research process.

As part of the implementation of Step 1A, the implementation team should identify megatrends, i.e., fundamental phenomena that are very likely to occur in the long run. In the context of the impact of megatrends on the development of a given city, this analysis should be carried out with the use of desk research and web research methods. Megatrends are a good tool to be used on a city scale, for each of its areas of operation—for instance, in the energy sector, where the life cycle of large electricity or heat generation installations usually exceeds thirty years. In this way, when deciding to build a power plant these days, it is important to bear in mind conditions that will arise in the perspective of, e.g., 2050 [96].

Step 1B is aimed at identifying internal and external factors determining smart city development, based on the results of megatrend analysis as well as further use of desk research and web research in order to identify conditions for the development of the city at a local, regional and national level. The result of the work of the implementation team may be individual cards of identified factors from seven areas of the STEEPVL analysis: social (S), technological (T), economic (E), ecological (E), political (P), relating to values (V) and legal (L) [95,97]. In the next step, the implementation team, using the brainstorming method, should complete the final list of STEEPVL analysis factors, which is the starting material for the next step.

Step 1C should focus on identifying key factors in each of the identified groups of STEEPVL analysis factors. Their selection should be made by city development stakeholders who are part of the citizen panel. During the panel meeting, each member should select a specific number of factors in each of the groups which, in their opinion, are most important from the point of view of smart city development. The number of the most important factors may be limited from three to five in each group.

Step 1D should be aimed at the evaluation of the list of key factors of the STEEPVL analysis in terms of their importance and predictability for smart city development. This approach is primarily focused on identifying the most relevant factors that are potential driving forces of the resulting scenarios. Assessment should be made taking into account a specific time horizon (e.g., 10, 20, 30 years). The members of the citizen panel should make an assessment of the importance and predictability of the factors by means of a seven-level Likert scale, using a research form constituting the PAPI (Paper and Pen Personal Interview) or CAWI (Computer-Assisted Web Interview) survey.

The aim of Step 1E is to determine interrelationships between major factors in the STEEPVL analysis. This assessment should be made by the members of the citizen panel, and also with the use of an electronic research form constituting the CAWI or PAPI survey. Stakeholders should determine whether and to what extent individual factors affect other factors. Assessment should be made on a scale from zero to three (0, no impact; 1, weak impact; 2, medium impact; 3, strong impact) for each pair of factors.

In Step 1F, the implementation team should prepare a resultant matrix of mutual influence of STEEPVL factors, which can be analysed with the use of MIC-MAC software [98]. This analysis will lead to the distinction of groups of factors influencing smart city development, divided into: key, determining, regulating, auxiliary, independent, goals and results and external. The aim of the structural analysis is to identify key dependencies of STEEPVL factors with regard to their strength of impact. Their comparison with the results obtained during the assessment of the importance and predictability of the factors should be an important stage in the development of smart city development scenarios. Key factors identified at this stage with a high level of importance and low level of predictability and the highest degree of influence on other factors and dependencies on them may become axes of smart city scenarios. A regional project relating to the development of nanotechnology [97,99] and universities [100] in Poland constitutes an example of a description of research with the use of the STEEPVL and structural analyses.

In order to identify factors constituting scenario axes (driving forces), it is advisable to organise a workshop with the participation of members of the citizen panel. The results obtained so far should be presented over the course of a meeting. During discussions, stakeholders should be asked to express their opinions on factors that are the driving forces of development scenario axes. If the number of factors is higher than three, stakeholders should vote in order to make a clear choice between two of them.

Figure 5 presents a diagram of the operationalisation of Stage 2. Six research steps are presented in connection with the research methods: Delphi, citizen panel, brainstorming. The main research method is Delphi, with an aim to providing material for development scenarios and collecting data for the NCRR method.

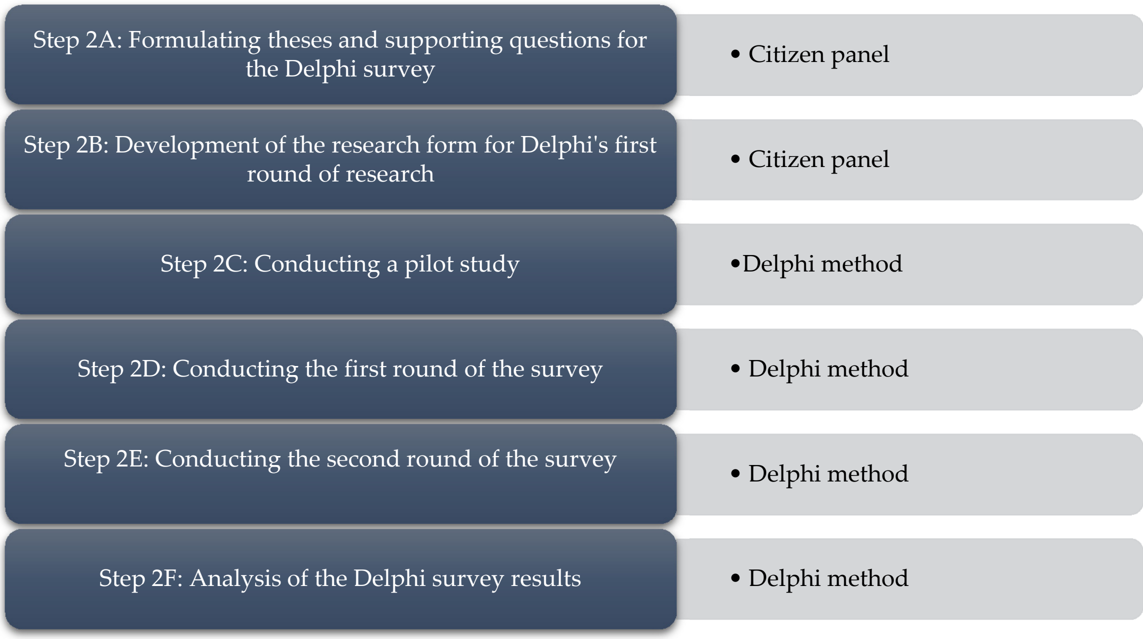

Figure 5. Operationalisation scheme for Stage 2 of the research process.

In Step 2A, the citizen panel should formulate a set of theses and supporting questions for the Delphi method. The Delphi technique is a forward-looking description of the relationship between issues arising from the specificity of the study and the context determined by the study objective. It is a research question related to the future, presented in the form of a thesis. Supporting questions should include such elements as the time of thesis implementation, probability of its occurrence, factors supporting thesis implementation, barriers to thesis implementation and expected effects of thesis implementation [101–104]. It is important that the members of the citizen panel are involved in the development of Delphi theses. They can be divided into groups and formulate theses in relation to a specific area, e.g., infrastructure, environment, energy, security, transport, social policy, etc. The work of the implementation team should lead to the elaboration of questions that are auxiliary to the Delphi theses.

Step 2B should focus on preparing a research questionnaire for the first round of the Delphi survey. Research material obtained in Step 2A should be used in the preparation process. It should be selected and analysed by the implementation team with regard to its methodical and factual correctness. The team should also identify potential participants in the pilot and proper study from a wide range of stakeholders in city development. When selecting stakeholders for the Delphi survey, targeted recruitment and snowballing is recommended. The group should be diversified in terms of the represented professional sphere, education, gender and age.

Step 2C is aimed at conducting a pilot study using the CAWI survey within a group of several respondents. This measure allows for the verification of the questionnaire in terms of its comprehensibility, as well as the elimination of errors from its final version.

Steps 2D–2F are related to the Delphi method. In its first round, the CAWI questionnaire should be dispatched to a specific group of city stakeholders. Once the results have been obtained, the form should be developed for round 2 of the survey, including summary statements and selected comments from round 1. In the second round of the survey, respondents will be able to change their opinion based on the knowledge of others [104]. The developed survey form should be sent only to those respondents who participated in the first round of the survey. After obtaining the results from the second round of the survey, the implementation team should make a final analysis and interpretation of the results. The obtained data will constitute the input to smart city development scenarios. By means of the Delphi survey, it is possible to verify the correctness of the definition for scenario axes. The obtained results illustrate the conditions of implementing individual scenarios and the probability of their occurrence. The research with the use of the Delphi method is best described by foresight conducted for the city of Newcastle [54] and regional foresight related to the development of tourism in Poland [105].

Figure 6 presents an operationalisation scheme for Stage 3 of the research process. It consists of three steps related to four research methods: creative visioning, scenario method, citizen panel and brainstorming.

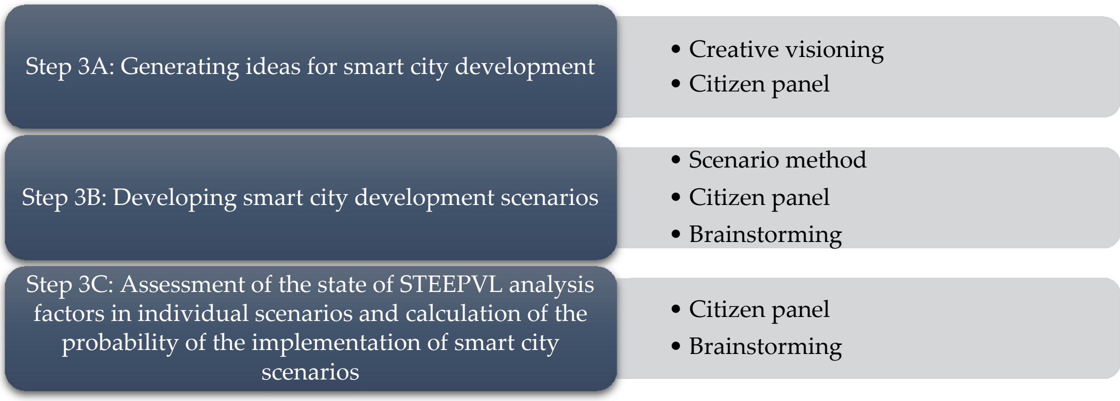

Figure 6. Operationalisation scheme for Stage 3 of the research process.

Step 3A should incorporate the creative visioning method in order to generate ideas for measures aimed at smart city development as part of the work of the citizen panel. The members of the citizen panel can work individually, as well as merge into groups. The method can be used only after developing tools that constitute a research form with questions about the future. They can be formulated in the form of unfinished sentences referring to a specific time perspective—for example, 2050 [54]:

- Where I live in 2050 is ...
- What I wish was different is ...
- In my free time, I ...
- The main thing I worry about is ...
- What I love about my city is ...

During the meeting, the members of the citizen panel may provide answers in writing, but a graphic form (e.g., drawings) may also be an interesting solution. Foresight projects conducted for the cities of Newcastle and Cambridge in United Kingdom provide examples of the description of research with the use of the creative visioning method [54].

Step 3B should lead to the formulation of smart city development scenarios based on the results of the STEEPVL analysis, structural analysis, the Delphi method and creative visioning. These scenarios can be built on the basis of two key factors identified as a result of the first stage of the research process. The identified factors should be applied on two axes, leading to the creation of a matrix. The upper right field will have a positive meaning and the lower left field a negative meaning. The other two fields will take the positive and negative values of the first or second factor, respectively. This will result in four scenarios showing different visions of how the future of a smart city may develop. Alternative states of the future developed with the use of the scenario method should create a coherent, reliable picture of smart city development [106–108]. In this way, it is possible to show not only the most probable or desired developments, but also alternative versions. The three Ps, i.e., the division into visions: the predictable, the possible, and the preferred, is the most frequently applied method [109]. Foresight projects conducted for the cities of Rochdale in United Kingdom [54], Lublin in Poland [75] and Rustavi in Georgia [76] extensively describe research with the use of the scenarios method.

In Step 3C, the citizen panel should focus on assessing the status of other factors in the STEEPVL analysis in each scenario. It is also advisable to develop the characteristics of individual smart city development scenarios in a specific time perspective. Calculations can be made on the basis of the results of the Delphi study in relation to two theses closely related to the axes of smart city development scenarios.

Figure 7 illustrates the operationalisation scheme for Stage 4 of the research process. It consists of three steps related to five research methods: the NCRR, citizen panel, brainstorming, surveys and conferences.

Figure 7. Operationalisation scheme for Stage 4 of the research process.

In Step 4A, the main research method is the NCRR. It involves identifying actions related to smart city development divided into four categories: new, so far not undertaken (N); implemented so far, to be continued (C); redundant, to be discontinued (R); actions that have been implemented in the past and to be restored (R) [94]. Actions may also be grouped in such specific areas as infrastructure, environment, energy, security, transport, social policy, etc.

As part of Step 4B, the identified catalogue of actions divided into individual categories (according to the NCRR method) in the form of the CAWI or PAPI survey should be distributed to a wide range of stakeholders (primarily those participating in the Delphi survey). Each of these respondents should indicate the three most important activities which, in their opinion, will have an impact on the implementation of the selected scenario (depending on the choice—the most probable or the most desirable) in a specific time perspective. In case of grouping activities into narrower research areas, the three most important ones should be selected from each of them. The result of the NCRR survey will be a set of priority actions allowing for the achievement of a specific vision of the future.

Step 4C should involve a conference for a large number of stakeholders. It should focus on the discussion of development scenarios and a proposed catalogue of priority actions. This discussion and its findings may lead to the completion or modification of the final catalogue of priority actions for smart city development. Research with the use of the NCRR method can be exemplified by a regional foresight project relating to the development of tourism in Poland [94].

Figure 8 presents the operationalisation scheme for Stage 5 of the research process. It illustrates four steps in connection with the following research methods: citizen panels, conferences and surveys.

Figure 8. Operationalisation scheme Stage 5 of the research process.

Step 5A is based on the regular organisation of conferences reminding stakeholders about the vision of smart city development. The conference should primarily focus on making participants implement the developed activities and solutions in the course of their professional and social activity. Such meetings should be organised in various places, districts, institutions in the city. They should be accompanied by other initiatives, interesting from the point of view of the development of the city and to inhabitants of different ages, including, for example, lectures, training and workshops.

Step 5B concerns the evaluation of the implementation of the vision and the formulated priority actions. This step should be carried out by the implementation team with the involvement of the members of the citizen panel, who have detailed knowledge of the research process and the results achieved. Evaluation should be carried out with the use of, e.g., the CAWI and PAPI surveys.

The implementation of Step 5C should be aimed at taking action to resume the research process. Reactivation of the foresight research cycle should start after a certain time (e.g., after several years). This step should also involve a conference during which the results of the evaluation study will be presented and confronted with the stakeholders. Discussions may provide information on the need (or lack of it) to resume the process.

5. Conclusions

The application of foresight in the process of planning and implementation of the vision of smart city development can bring many benefits. First of all, it enables undertaking intelligent planning activities, setting sustainable development priorities as well as building pro-social and pro-innovative policies in the city. It fosters the development of forward-looking, long-term scenarios of the smart city development vision, taking into account a wide range of social, economic, technological, political, legal and environmental conditions [110]. It also helps to assess the consequences of current actions and detect problems before they occur, thus allowing for their avoidance [111,112].

Foresight is a process where one of its indispensable elements is social participation. The idea of foresight initiatives is to involve a wide range of stakeholders in the process of creating a vision of smart city development. It involves a wide range of stakeholders from various spheres: entrepreneurs, scientists, representatives of administration, non-governmental organisations, the media and inhabitants of various ages with diverse knowledge and experience in the field of city development, who, through their bottom-up view of the research problem, can make the formulation of development visions much more realistic. These visions should take into account the complexity of the urban system and skilfully use its potential [113] to better respond to social, economic and environmental change.

Foresight initiatives foster a dialogue between research participants and provide a framework for communication and sharing of insights into possible future developments in a smart city. The use of foresight as a process to identify future events and make participants aware of their ability to influence changes in the city through a pro-active attitude is more useful in practice than previously used activities aimed at anticipating and forecasting the future. Foresight does not assume the existence of a single, strictly defined future. Depending on the level of stakeholders' activity and the range of activities to be undertaken in the present, many versions of the future are possible. However, it should be remembered that only one of them will come into existence.

The involvement of a large number of stakeholders is also a key element in the process aimed at the implementation of the obtained results and practical use of the generated knowledge. Foresight, through wide-scope involvement of its participants, facilitates their mutual learning and, as a result of many discussions, leads to social acceptance of the designated directions of development. The participation of stakeholders at each stage of obtaining results shapes their awareness of being co-creators, which also triggers the assumption of responsibility for their implementation of the results into their everyday professional and private activities. The success of the process does not depend only on a properly designed sequence of research activities that allow for achieving a synergistic effect, but, above all, also on the involvement of stakeholders in smart city development, whose knowledge and experience will make it possible to implement priority actions. The use of foresight also creates conditions for the creation of partnership networks through which joint initiatives in specific areas of the smart city can be undertaken. Such an activity also allows for the formation of a culture of thinking oriented towards co-learning, co-creation and co-intelligence.

Foresight research must be carried out systematically in order to bring measurable benefits. Iterative periods of open discussion, consultation, networking can lead to achieving measurable results. Successive repetition of such research allows for updating the developed priorities and visions of the future in the context of ongoing changes, as well as monitoring the effects obtained by means of, e.g., the implementation of the developed foresight results by decision-makers and stakeholders. The repetitiveness of the process will contribute to its acknowledgement as a permanent approach in thinking about the future of the smart city and a useful tool for managing it.

The results obtained within the foresight research can definitely be used as a set of data and proposals for socially acceptable solutions in creating long-term strategies for smart city development, preparing/improving smart city spatial development plans, developing environmental protection programmes, social integration plans and many other important documents from the point of view of smart city functioning. Urban decision-makers may, on the basis of the results obtained within foresight research, divide tasks to be performed by particular organisational units within city authorities. They may also create a separate organisational unit for smart city foresight or for the implementation of future visions of a smart city. This unit will be responsible for dividing tasks between organisational units within city authorities, monitoring the progress of implementation and regularly resuming the foresight research process in specific time perspectives.

Planning tools connected with the classic model of public city management are oriented around the top-down decisions of city decision-makers or the engagement of experts in developing strategic documents or assumptions of specific projects. Foresight, on the other hand, makes it possible to gather opinions and gain benefits from the expert knowledge of a wide range of stakeholders. This tool allows for an examination of which solutions are important and necessary from the point of view of society and which, despite their potential (e.g., technological), will not be used by society due to a variety of factors (e.g., social, economic, environmental or value-related factors). For example, advanced technological solutions, considered by constructors and engineers as responding to social needs, may be of little or no use to them and their environment.

This can be exemplified by a measure related to the installation of innovative LED lighting in city streets. Its benefits will definitely include, e.g., saving electricity and increasing safety. The indicated benefits constitute a single-sided aspect. Foresight, through the involvement of a wide range of stakeholders, provides an opportunity for a multidimensional view of the issue under consideration, open to the emergence of different opinions that concern a given solution. For instance, high expenses related to the installation of innovative LED lighting may result in the failure to meet other more important needs of the residents (particularly in the context of an aging society), e.g., the construction and functioning of the city centre for senior citizens. Such problems can be avoided by collecting opinions from a wide range of stakeholders representing different social groups (of different ages, professions) and by using various foresight research methods (qualitative and quantitative, scientific and heuristic). Unfortunately, when designing solutions with the sole participation of the representatives of public administration or field experts, there is a high probability of narrowing down the view on smart city development.

A skilfully prepared strategy of a coherent, logical and long-term character, responding to signals coming from the environment will enable a smart city to take actions aimed at necessary, thorough transformations that condition sustainable development of the area. At the same time, it will constitute a tool counteracting accidental and chaotic decisions.

The presented methodology was developed on the basis of recommendations and good practices available in the literature, as well as the author's personal experience gained in the course of executing foresight projects. The article takes into account the fact that, apart from determining the methodology of the study, there are many other issues that need to be answered in detail. First of all, they concern the principles and methods of selecting implementation team members and stakeholders, determining the time horizon of the research, methods of maintaining the activity of stakeholders at each stage of the research process, expected results, the evaluation process and the designation of entities responsible for implementation. These issues, due to their relevance, require separate considerations for each city where the process is to be implemented.

The paper takes into account the limitations of this research, i.e., that the proposed methodology of planning and implementing the vision of smart city development has not yet been tested in practice. Its validation via its implementation in selected cities (diversified in terms of size and socio-economic development) is a further step in the planned research process. The methodology of planning and implementing the vision of smart city development presented in the article is not finite or unchangeable. In the course of the research into its application, if necessary, it can be flexibly adapted to the specific needs of individual cities and their inhabitants.

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