OPEN ACCESS

Vol 5, No. 2, 2018, 205-214

Geoplanning
Journal of Geomatics and Planning
E-ISSN: 2355-6544
http://ejournal.undip.ac.id/index.php/geoplanning
doi: 10.14710/geoplanning.5.2.205-214

POTENTIAL OF BIG DATA FOR PRO-ACTIVE PARTICIPATORY LAND USE PLANNING

W.T. de Vries[a]

[a] *Department of Civil, Geo and Environmental Engineering, Technical University of Munich, Germany*

Article Info:
Received: 30 June 2018
in revised form: 15 Sept 2018
Accepted: 15 October 2018
Available Online: 25 October 2018

Keywords:
Big data, Land use planning, smart cities, land management, participation.

Corresponding Author:
Walter Timo de Vries
Technical University of Munich, Germany
Email: wt.de-vries@tum.de

Abstract: *The presence of (spatial) big data presumes that citizens can more actively collect and analyse data for their own land use goals. This article evaluates that claim. Given that land use planning heavily depends on participation and citizens own contributions the core question is whether and how (spatial) big data can enhance and or complement current land use planning endeavours. The article starts by defining and conceptualising the various phases and objectives of land use planning. This is needed to verify where citizen participation can play a crucial role and where bottom-up influence can aactually emerge. The article is fundamentally explorative. It relies on evaluating existing websites and documentation which conceptualise (spatial) big data and smart application, with a particular emphasis on 'smart people'. A number of specific cases are explored in order to verify how and in which type of land use planning activity citizens are actively. The evaluation indicates that many the smart application making use of big data are still largely driven by conventional hierarchical governance structures. The choice of data and associated analytics are still largely confined and opportunities whereby the designs of the new and alternative land use option by citizens are accepted or adopted is still limited. The take-home message is that adoption of big data for the purpose of empowering citizens is still limited. There probably needs to be more exemplary projects and various forms of capacity development and exploratory pilots before the full potential of (spatial) big data can be employed for bottom-up land use planning.*

de Vries, W.T. (2018). Potential of Big Data for Pro-Active Participatory Land Use Planning. *Geoplanning: Journal of Geomatics and Planning, 5*(2), 205-214. doi: 10.14710/geoplanning.5.2.205-214

1. INTRODUCTION

Globally the impacts of land use, land occupation and allocations of land rights are changing. Emerging effects include increasing land scarcity (Gerber, Hartmann, & Hengstermann, 2018), rapid urbanization and growing hazards whereby ever larger numbers of people are at risk. This situation calls on the one hand for information sources which are available instantly and which have better quality, reliability and actuality, and on the other hand for planning processes which rely on more active participation and co-creation of citizens and enhanced informed decision making mechanisms.

The rise of big, open, linked and voluntary data is claimed to (partly) address the former, whereas the renewed interests in concept of the 'right to the city' (Brenner et al., 2012; Mayer, 2012), the experiments of co-creation of spatial design and spatial governance (Franz, Tausz, & Thiel, 2015; Rooij & Frank, 2016), and the occurrence of neo-cadastres (De Vries, Bennett, & Zevenbergen, 2015) amongst others may address the latter. What are these developments however, and to which extent are they truly changing the landscape and the practice of spatial planning? The main research question of this article is Does the presence of spatial big data-(1) increase the number of citizen-driven land use planning contributions; (2) Improve the quality with which citizens can actively collect and analyse data to pursue their own land use goals; and (3) make citizens smarter.

This article discusses first qualifications and appraisals of big data, with a particular focus on geospatial or geotagged/georeferenced big data. This discussion also highlights a number of current concerns, i.e. dangers for privacy, unequal access, digital divides, etc. After this review on spatial big data, it discusses the variations in spatial and land use planning. This discussion is necessary to understand where and how big data can play a role in which parts or which phases land use planning. This includes a review of goals, tools and instruments in the different types of spatial planning, including the role of geospatial tools and instruments in spatial (land use) planning.

Part of this discourse is a specific focus on smart cities and smart (rural) regions. It is therefore crucial to understand how big data are influencing the 'smart' land use planning. This article will focus specifically on the element of 'smart people' and a classification of how and where smart people play a role in different actions and phases of land use planning. With this classification different examples in Germany of smart people applications in spatial planning are discussed and reviewed in order to answer the research questions more specifically. The conclusion section then discusses how the research questions can be answered and what sort of further research is required to obtain a better understanding of the role and potential of big data in spatial land use planning.

2. DATA AND METHODS

2.1. Qualification and Appraisals of (Spatial) Big Data

Big data have gained a significant place in the discourse of multiple domains. However, in these discourses one can also observe a number of developments and variations in understanding and defining big data. Batty (2013) characterizes big data as '*any data that cannot fit into an Excel spreadsheet*'. However, size is not the only characteristic of big data. Schintler & Chen (2017) and Doornik & Hendry (2014) classify further that big data can be 'fat' or 'tall'. Fat data has many attributes 'M' but lesser number of observations 'N' , while tall data has few attributes but many observations (M<N).

French, Barchers, & Zhang (2015) compare the structure of big data to traditional data indicating big data infrastructures are far more 'unstructured': many of these records are tagged with geolocation or a time stamp, and sometimes both, time or location can often be used to join otherwise unrelated data sets. In addition to this traditional structured data, we now have vast amounts of unstructured data (e.g. drone videos, Tweets, Facebook posts, YouTube videos, foursquare check-ins, surveillance videos and much more).

The EUCLID Project (http://euclid-project.eu/modules/chapter6.html) refer to big data as having three key aspects, referred to as the 3Vs of Big Data: variety, volume and velocity (Laney, 2001; Schintler & Fischer, 2018) add a fourth dimension: Veracity. This has a lot to do with trueness and uncertainty of the sources and validity of the data. Discussions on fake news Facebook and those of Cambridge Analytica have also given rise to look critically at who owns which data and how third parties use data. Regardless of these, Table 1 summarizes the characteristics of these 4Vs. Recent discourses even add a 5thV, namely Value. However, this specific V does not yet occur in many other literature sources, despite its obvious relevance. Another distinction related to big data is the difference between 'big' and 'small' data. Kitchin & Lauriault (2015) list the following differences (Table 2).

Table 1. Thee 4Vs of big data

	Variety	Volume	Velocity	Veracity
Data characteristic	Structured, semi-structured and unstructured	Large volumes of data	Streams, sensors, near real-time data, IoT	data may come from unknown or everchanging sources
Challenge	Data integration	Reasoning and querying	Reasoning & querying	quality of data is uncertain and from unverified sources
Solution	Semantic technologies are a good fit	Distributed storage & processing, parallel processing	Stream reasoning & querying	avoiding noise and abnormalities in the data

doi: 10.14710/geoplanning.5.2.205-214

Table 2. Differences between big and small data

	Small data	Big data
Volume	Limited to large	Very large
Exhaustivity	Samples	Entire populations
Resolution and identification	Course & weak to tight & strong	Tight & strong
Relationality	Weak to strong	Strong
Velocity	Slow, freeze-framed/bundled	Fast, continuous
Variety	Limited to wide	Wide
Flexible and scalable	Low to middling	High

The manner in which big data can be constructed or sourced depends largely on the manner in which these data are generated. On the one hand, one can distinct active to passive sensors or technical and human sensors, on the other one can make a distinction between user-generated, transaction-generated and sensor-generated big data. The crucial differences in the latter qualification are given in Table 3.

Table 3. Data sources of big data (*Senatsverwaltung für Stadtentwicklung un Wohnen Berlin*, 2017)

User generated data	Transaction-generated data	Sensor-generated data
Photo-platforms	Mobility platforms	Navigation systems
Rating-platforms	Real estate portals	Mobile phone data
Map portals	Hotels platforms	Surveillance data
Social media	Tenders	Building data
GPS tracking	Exchange / sharing platforms	Biometric data
Search portals	Job platforms	
Wikis	Online business	
Dating portals	Mobility data	
Business networks		

Constructing big data can be done in multiple ways. The comprehensive document by the Senatsverwaltung für Stadtentwicklung un Wohnen Berlin (2017) lists these possibilities: (1) Via Application programming interfaces (APIs) – e.g. Twitter, Flickr, Openstreetmap; (2) Via Webscraping – extracting of data via websites – clicking on links, completion of forms, scrolling; (3) Via making data sources available for commercial purposes; (4) Data brokers – e.g. Airdna (for Airbnb), Gnip (Twitter and diverse data sources of user-generated data) and Quintly; (5) Via communities – e.g. data journalists, open communities.

This list shows indeed the large variety in platforms, content, shapes and formats. What makes big data '*spatial* big data' is the specific georeference. Schintler & Chen (2017) indicate how such georeference can be added to the data being constructed through the above listed possibilities and thus create *spatial* big data: (1) Geo-tagged photos; (2) Weather data (hourly, daily); (3) GPS trajectories; (4) SNS Check-in records (twitter, facebook, etc.); (5) Earth observation imagery; (6) Public transportation card transactions; (7) Spatial events, e.g., crimes, accidents; and (8) Climate model simulations.

Research based on spatial big data requires however spatial analytics. The analytics needs to capture for example certain spatial patterns which cannot be seen by simple visual observation, and needs to be able to make predictions based on such patterns. Spatial analytics, in other words, the capability to automatically derive predictions of spatially distributed features and phenomena, patterns of spatial collocation of factors or indicators which were previously not considered connected, finding hotspots of certain manifestations of phenomena, and needs to find changes and outliers in spatial patterns.

doi: 10.14710/geoplanning.5.2.205-214

2.2. Changes and Variations in Land Use Planning

It is however not only the manner in which data are being constructed which is changing, also the way of land use planning is conducted changes. Although literature is fairly consistent on what land use planning entails and what its goals are, at the same time there are variations on a similar theme. These variations have to do with different emphases in the professional and/or institutional set-up of land use planning systems in different countries and in the degree and type of experience gained with land use planning in different environments.

A commonly used classification of land use planning is that from GIZ (Wehrmann, 2012), which refer to land use planning as an iterative process of six phases (Figure 1): definition of objective and approach; analysis; plan formulation; approval; implementation; monitoring. Each phase has distinct characteristics and requires specific kinds of (spatial) data and associated (spatial) and social analytical tools. Lagopoulos (2018) uses a different kind of description, referring to eight interconnected stages or actions (Figure 2): decision to intervene; survey of spatial system; policy making (alternative scenarios); forecasting; model of spatial system; alternative spatial scenarios; evaluation and selection; implementation. Metternicht (2018) list different variants of land use planning, which either reflect different traditions or different foci. Table 4 list a number of such variants.

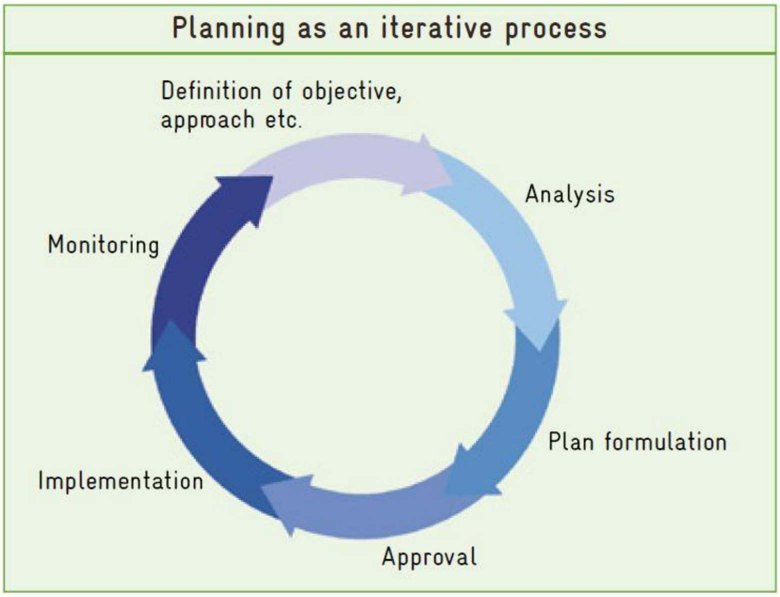

Figure 1. GIZ phases of land use planning (Wehrmann, 2012)

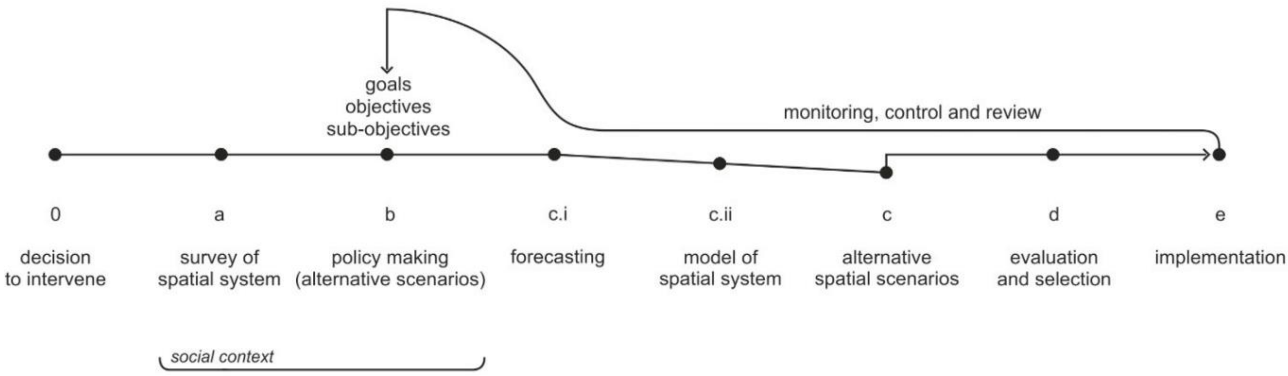

Figure 2. Land use planning stages or actions (Lagopoulos, 2018)

Table 4. Examples of land use planning variants (Metternicht, 2018)

Variants of land use planning	Description
Land use planning	Systematic assessment of land and water potential, alternatives for land use and economic conditions, in order to select and adopt the best land use options
Spatial land use planning	Interdisciplinary and comprehensive approach directed towards balanced regional development, and the physical organization of space according to an overall strategy
Integrated land use planning	Assessment and assignment of use of resources, taking into account different users, including all agricultural sectors- pastoral, crop and forests – as well as industry and interested parties
Participatory land use planning	Planning of communal or common property land, important in many communities where lands are degraded, and where conflicts over land use rights exist
Regional land use planning	Process of territorial development designed to facilitate the elaboration of a general spatial concept and land use priorities

2.3. Smart cities and planning

Once the spatial data are connected and/or integrated to the various forms, phases and spheres of land use planning, one can start to speak about *smart* land use planning. Being or acting *smart* assumes however a number of things. Literature on smart cities makes a specific set of characteristics whereby 'smartness' can be evaluated: smart economy, smart mobility, smart governance, smart environment, smart living and smart people. The benchmarking ranking model by the smart cities projects (http://www.smart-cities.eu) employs these six characteristics to rank cities in Europe on the degree of smartness. Crucial for land use planning is hereby the connection between technologies which may be employed for each of the phases on land use planning but also the degree to which people can actively contribute by creating their own data.

The latter is evaluated in the ranking of smart people, which is ranked specifically as well (see Figure 3). What is remarkable in this project with respect to this specific article is that the German cities relatively rank low on this list regarding the smart people characteristic. This is not to say that German cities are not smart, but that the degree, to which people are actively contributing to the smartness of the cities, including the usage of big data, seems relatively low.

City	Eco	Peo	Gov	Mob	Env	Liv	Total
LU LUXEMBOURG	1	18	56	4	16	4	1
DK AARHUS	2	3	6	3	19	27	2
SE UMEAA	24	5	2	34	1	13	3
SE ESKILSTUNA	21	1	7	24	3	41	4
DK AALBORG	10	11	5	14	14	10	5
SE JOENKOEPING	32	13	3	11	2	26	6
DK ODENSE	13	9	4	20	9	40	7
FI JYVÄSKYLÄ	23	8	1	47	5	25	8
FI TAMPERE	16	2	15	31	12	14	9
AT SALZBURG	27	24	29	2	27	1	10
FI TURKU	20	6	12	15	18	29	11
FI OULU	14	4	9	39	13	35	12
AT INNSBRUCK	35	27	26	12	6	3	13
AT LINZ	11	23	31	8	25	7	14
SI LJUBLJANA	6	7	34	33	21	21	15
AT GRAZ	26	21	33	9	28	2	16
NL EINDHOVEN	5	12	24	1	49	49	17
DE REGENSBURG	4	17	37	10	37	11	18

Figure 3. Excerpt from the European smart cities project (http://www.smart-cities.eu)

doi: 10.14710/geoplanning.5.2.205-214

3. RESULTS AND DISCUSSION

3.1. German cases of use of big (spatial) data and smart planning

In order to evaluate the usage of spatial big data more specifically in Germany cases, examples were extracted from the following sources: (a) Big Data und Crowd Data für die Berliner Stadtentwicklungsplanung [1]; (b) European list smart cities TU Wien [2]; (c) Smart Cities in Deutschland: So digital Sind unsere Städte wirklich[3]; (d) Digitale Stadt[4]; and (e) Land atlas Germany[5]. This list is by far complete, but it provides a good first insight in where and how data can be used specifically for land use planning. The study '*Big Data und Crowd Data für die Berliner Stadtentwicklungsplanung'* (2017) qualifies the usage of spatial big data by 'smart people' in land use planning based on two dimensions, there are the degree to which the targeted land use interventions are either specific or general, and the degree to which the targeted interventions are initiated and generated from the citizens (bottom-up) or by the government (top-down). With these two dimensions the examples can be qualified as in Figure 4. Table 5 lists examples, which were evaluated fitting these classifications of Figure 4.

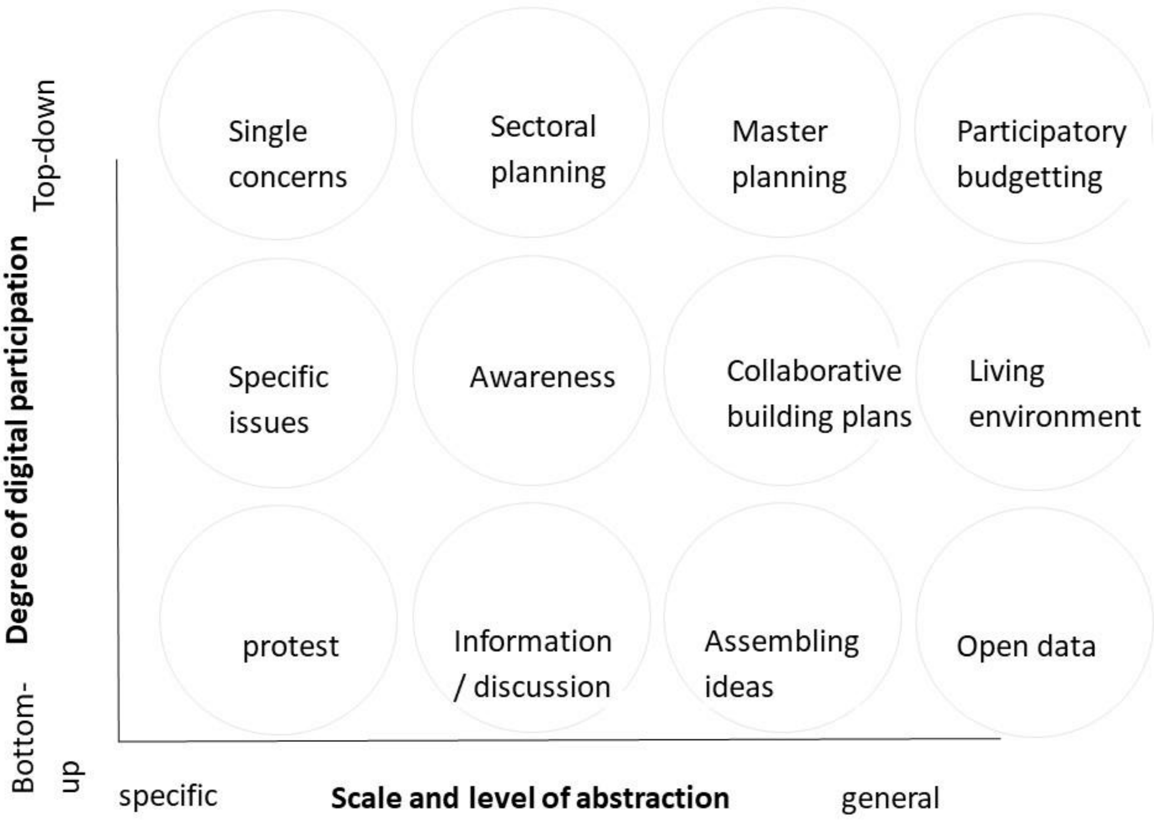

Figure 4. Qualification of smart people in land use planning

[1] https://www.stadtentwicklung.berlin.de/planen/basisdaten_stadtentwicklung/big-data/downloads/big-data_crowd-data_berlin.pdf.
[2] http://www.smart-cities.eu/
[3] https://www.wired.de/collection/life/smart-city-digitale-agenda-digital-smart-mobility-smart-carsharing-e-mobility
[4] https://www.bbsr.bund.de/BBSR/DE/Stadtentwicklung/StadtentwicklungDeutschland/digitale-stadt/digitale-stadt-node.html
[5] https://www.landatlas.de

doi: 10.14710/geoplanning.5.2.205-214

Table 5. Examples of land use planning with spatial big data

	Specific			General
Top down	Ludwigshafen diskutiert Wasserstadt dialog hannover	dialog luft und lärm leipzig radständer nürnberg	München Mitdenken Potsdam weiterdenken	Place2help Rhein-Main Bürgerhaushalt Berlin-Lichtenberg
	Sag's doch Friedrichshafen Flashpoll	Die urbanauten münchen Leerstandsmelder Critical mass Dresden	Bauleitplanung Lingen Planportal Hamburg	Digitale Dörfer Nebenan
Bottom-up	Recht auf Stadt Hamburg Viva Viktoria Bonn	Nordstadtblogger Dortmund Urbanophil berlin	openberlin Frankfurt gestalten	Hackaton Freiburg Code for Berlin

A number of these examples are discussed in more detail. Recht auf Stadt Hamburg ('Right to the city Hamburg), this specific case is part of a larger network http://www.rechtaufstadt.net/ . This website is a specific case of a bottom-up protest facility, providing an internet platform for citizens to share information on land use and property issues which are considered unfair, and on upcoming actions and events which require the mobilisation of people (such as protests, online petitions or demonstrations). The online facility currently focuses primarily on the high rents in cities and on the increasing difficulty for ordinary people to live affordably in the city. Currently there are however not so many maps or spatial big data used, although there would certainly be a potential for this. Examples such as https://www.antievictionmap.com/ in California/USA, showing maps, which display the location and degree of gentrification and locations of evictions for example, show that it is possible to go one-step further than simply informing and signalling problems. Instead one can advocate and using blame and shame techniques with such maps. Currently, however the Recht auf Stadt facility remains in the problem-framing sphere, instead of scaling it up to full collaborative problem solution tool.

The Leerstandsmelder ('Reporting vacant land and vacant buildings') is an example of an awareness raising facility developed by both local governments and citizens. The site uses a map facility to collect and display information about the location and type of vacant / fallow land and/or buildings. As such it can provide both governments, private parties and citizens an idea of where unused or underutilized land exists, and where potentially active land use planning measures could be taken in order to revitalize the land or building. As such it offers a good insight in potential development problem areas and it could help to mobilize resources to act upon this information. It actively makes use of webGIS technology to manage, locate and display the information. What is missing in this facility is, however, the possibility to interact with the information. Citizens are not able to actively engage with the facility with suggestions or requests, or to link the information to other types of (spatial big) data to see possible reasons or trends. Theoretically, such spatial analytics would be feasible. Mapreduce models and Hadoop open source software (https://hadoop.apache.org/) could potentially play a significant role here. Collaboration and engagement are enhanced with this tool in land use planning, but scenario building and seeking bottom-up based land use planning solutions is not yet possible.

Code for Berlin - https://codefor.de/berlin/ is an example of an open data project. Originating from a series of Hackatons, whereby voluntary programmers design code to generate software solutions for a given problem, it now functions as a platform whereby all types of algorithms and software can be shared. The openness makes it accessible for any citizen, so engagement is unlimited in theory. However, programming remains a complicated activity for many ordinary citizens and therefore remains a rather exclusive activity. Hence, the theory does not always translate practice. The scenarios and solutions may thus be limited to those are capable of handling the technology and as a result the technology is not value-free. At the same time, there are also a number of intermediaries which can play an active role in making the technology more accessible. Initiatives such as 52 North (https://52north.org/) and Runder Tisch GIS (https://rundertischgis.de/) aim at enhancing the utilization of open source spatial technologies in the field of spatial land use planning (Figure 5). Yet, as said, there is still a certain professional threshold to make this a fully citizen-based technology.

The project LandAtlas (https://www.landatlas.de) is a very independent project, but worthwhile mentioning here as it focuses specifically on rural areas. Combining different publicly available datasets (such as the ones published by the national planning and statistical agencies) it aims at deriving a rich picture of the current situation in rural areas. It uses thereby an integrated indicator on 'rurality', comprising of 5 other integrated indicators: Built-up area density, Proportion of agricultural and forest land, Proportion of family houses, Regional population potential and Accessibility to major centres. The combination of all these indicators, which are all georeferenced or geotagged, leads to a product LandAtlas. Through the LandAtlas it is possible to research interactively possible spatial correlations or associations at the lowest administrative scale. This type of information may be highly useful for citizens who aim to fact-check regional development indicators (e.g. is our region really shrinking or are only certain municipalities affected) and for those who may signal certain consistencies and inconsistencies (e.g. are public finances in line with gross local products or degree of public and private debts).

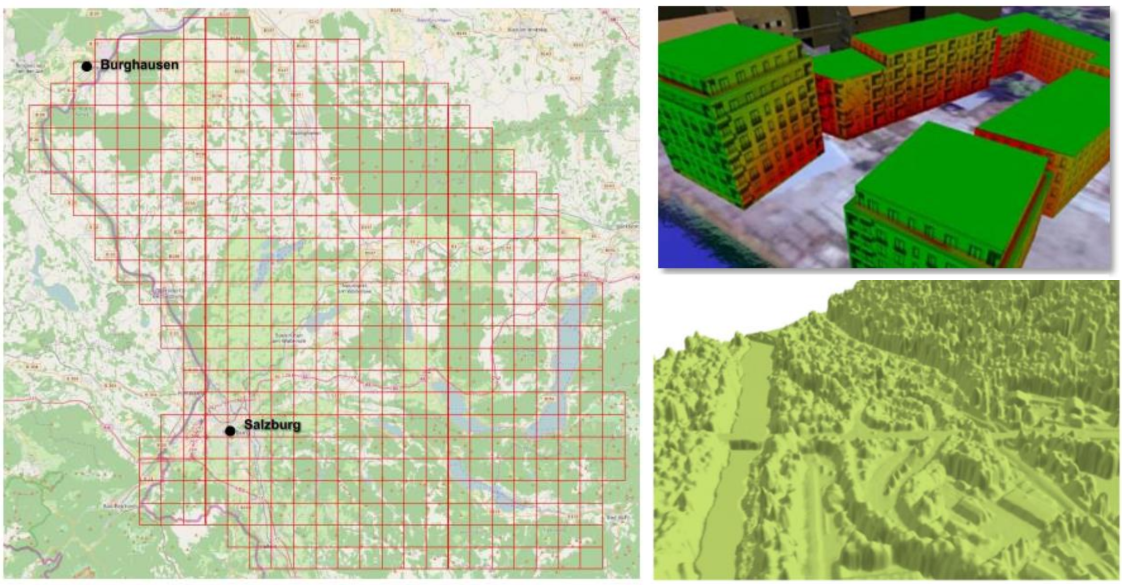

Figure 5. Big data for land Management in Germany (https://rundertischgis.de/)

3.2. Discussion

From the examples presented above one can observe that indeed many examples exist in Germany whereby citizens are actively or passively involved with spatial big data in different phases of land use planning. With reference to the typologies of Lagopoulos (2018), Metternicht (2018) and Wehrmann (2012) one could observe that most of the applications appear in both the definition and the plan formulation phase (using Wehrmann (2012)), the survey of social system and the policy making stage (using Lagopoulos(2018)) and the traditional land use planning variant (using Metternicht (2018)). This clearly leaves a number of potential incorporations, especially in the phases and stages of developing and comparing alternative scenarios, and in those critically evaluating the effectiveness of certain land use planning decisions, untouched.

The examples reveal also that maps and other forms of spatial data are not yet crucial in many strategic decision processes, and if they are, they heavily rely on professional geospatial technology expertise. The 'non-expert' examples are currently employed to signal, describe, display and categorize problems and to find and highlight issues. In addition there are examples whereby citizens advocate alternative forms of action and mobilise people, yet these are without any maps or spatial analytical functionalities. The examples given in Table 5 clearly indicate these types of actions. On the other hand, there are just very few good examples found in Germany whereby citizens - with the use of big spatial data - actively indicate or prepare land use zones, analyse the effectiveness or efficiency of public restrictions and sanctions, intervene in land use acquisition processes, demand alternative locations or blame and shame decisions, which were against public agreements. This seems to indicate that there are still spheres of land use planning where the usage of big spatial data is still limited. When we compare these spheres one could distinct four spheres in which citizens could potentially contribute in land policy formulation, land politics and organization of land and active contributions to land use planning decisions (Table 6).

Table 6. Four spheres of land use planning

Focus	Land Policy Formulation	Land Politics	(Public) Organization of Land	Citizens as contributors to land use planning
Traditional Land use planning	Policy process = Problem framing and agenda setting, policy development and decision making, policy implementation, policy control	Representation, idea generation and consideration, decision making and deliberation in parliament, democratic supervision	Executives; Strategic top; Operating Core; Technostructure; Support Staff	Citizens as rulers (participants in land use policy processes) Citizens as ruled (subject to authority, recipients of land use plan)
Smart big data driven Land use planning	Policy implementation; framing; protest	Democratic supervision; signaling problems (awareness & information)	Operating core; open portals; presenting integrated information	Citizens as consumers of services

4. CONCLUSION

In the context of the growing availability of spatial big data and in the light of the assumption that citizens use these spatial big data effectively and responsibly, this article questions the extent to which this assumption is valid. Based on an exploratory analysis of usage of big (spatial) data in Germany in the field of spatial planning the provisional conclusions are that there is indeed evidence of citizen-driven land use planning contributions, and the number of sites and the combined use of big data increases. Furthermore, one could see that the big data such as the ones assembled by LandAtlas start to derive new insights in local land use facts. Such new insights might support new discourses in what types of actions are useful and relevant. At the same time, the quality with which citizens can actively collect and analyse data to pursue their own land use goals can still be improved. There are indeed some active contributions, but there are also still many 'fake' or 'opportunistic' contributions. Hence, regarding the big data characteristic veracity there are still problems.

Regarding the overall question - do big spatial data already make citizens smart(er)? – One can only state partly. Despite the many cases of open issue developments and voluntary code development often citizens are still more consumers of the smart applications and not so often producers of complete and verifiable data. Smartness, in other words, therefore still seems to be more focused on enhancing smart economy and smart mobility for example in Germany and less on enhancing smart people. Possibly citizens are already actively engaged through conventional means in land use planning and do not require smart big data to enhance or increase their involvement. Another explanation could be that it remains still difficult to use spatial big data technologies and analytics for many unskilled people. This would suggest the need for more capacity development and the development of a sufficiently sized critical mass in this field. In both cases, the connection between geomatics, spatial planning and citizen sciences need to be improved and further developed.

5. REFERENCES

Batty, M. (2013). Big data, smart cities and city planning. *Dialogues in Human Geography*, *3*(3), 274–279. [Crossref]

Brenner, N., Marcuse, P., Mayer, M., & others. (2012). *Cities for people, not for profit: Critical urban theory and the right to the city*. Routledge.

De Vries, W. T., Bennett, R. M., & Zevenbergen, J. A. (2015). Neo-cadastres: innovative solution for land users without state based land rights, or just reflections of institutional isomorphism? *Survey Review*, *47*(342), 220–229. [Crossref]

Doornik, J. A., & Hendry, D. F. (2014). *Statistical Model Selection with "big Data."* University of Oxford, Department of Economics. Retrieved from https://books.google.co.id/books?id=whfOvQEACAAJ

Franz, Y., Tausz, K., & Thiel, S.-K. (2015). Contextuality and co-creation matter: A qualitative case study comparison of living lab concepts in urban research. *Technology Innovation Management Review*, *5*(12). [Crossref]

French, S., Barchers, C., & Zhang, W. (2015). Moving beyond operations: Leveraging big data for urban planning decisions. In *56th Annual Conference of Association of College Schools of Planning (ACSP), Portland*.

Gerber, J.-D., Hartmann, T., & Hengstermann, A. (2018). *Instruments of land policy: Dealing with scarcity of land*. Routledge.

Kitchin, R., & Lauriault, T. P. (2015). Small data in the era of big data. *GeoJournal*, *80*(4), 463–475. [Crossref]

Lagopoulos, A. (2018). Clarifying Theoretical and Applied Land-Use Planning Concepts. *Urban Science*, *2*(1), 17. [Crossref]

Laney, D. (2001). 3D data management: Controlling data volume, velocity and variety. *META Group Research Note*, *6*(70), 1.

Mayer, M. (2012). The "right to the city" in urban social movements. In *Cities for people, not for profit* (pp. 75–97). Routledge.

Metternicht, G. (2018). *Land Use and Spatial Planning: Enabling Sustainable Management of Land Resources*. Springer.

Rooij, R., & Frank, A. I. (2016). Educating spatial planners for the age of co-creation: the need to risk community, science and practice involvement in planning programmes and curricula. Taylor & Francis.

Schintler, L. A., & Chen, Z. (2017). *Big Data for Regional Science*. Taylor & Francis. Retrieved from https://books.google.co.id/books?id=txIwDwAAQBAJ

Schintler, L. A., & Fischer, M. M. (2018). *Big Data and Regional Science: Opportunities, Challenges, and Directions for Future Research*. WU Vienna University of Economics and Business.

Senatsverwaltung für Stadtentwicklung un Wohnen Berlin. (2017). *Big Data und Crowd Data für die Berliner Stadtentwicklungsplanung*.

Wehrmann, B. (2012). *Land Use Planning: Concept, Tools and Applications*. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).