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Social topography: Studying spatial inequality using a 3D regional model☆

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ABSTRACT

This study's point of departure is the need to develop a new theoretical language and tool-box to contend with the rising inequality that continues to expand under the spatially intensive and high density conditions stemming from demographic growth and large migration movements. Its response to this challenge is a 3D regional model based on the immersive visualization theater (VizLab) maintained by the Technion's Faculty of Architecture and Town Planning. Following the breakthrough in research on spatial inequality facilitated by VR technology, we propose "social topography" as a theory and a modelling method that stands to make a significant contribution to both qualitative and quantitative research methods. Social topography, we maintain, creates a new sociology: one of contour lines and spatially embedded hierarchies that exists under VR conditions and enables us to put on 3D glasses and go where the research community has not yet gone before.

This article's point of departure is the assumption that the world 'out there' contains inequality that continues to expand and intensify on different scales in various parts of the world, as reflected in reports of scholars in the United States and countries of the European Union (OECD, 2016: 74; Hopkin and Lynch, 2016). Inequality is also currently on the rise in Israel[1] and its southern periphery.[2] This study is a response to two calls to enhance both theory and methods regarding (rural) sociology of inequality: the theoretical Lacuna advanced by Vertovec (2007) in the field of social geography, and another that emerged from the field of rural sociology (Lobao, 1996), which advocates an enhancement of the conceptualization systems and research tools used by scholars of rural studies when addressing the relationship between society and space, and issues of inequality in particular. This call was also voiced in the field of the sociology of space, especially with regard to the sociology of spatial inequality (Tickamyer, 2000: 806). "Why do we routinely recognize that gender, race, class, and a variety of other 'categorical' sources of inequality constitute material social relations and inequalities, but fail to give equal recognition to spatial categories?" (Tickamyer, 2000, 808) asks Tickamyer, who identifies the primary challenge as the evolution of inequality and the need to bolster conceptualizations and research tools:

> Spatial relationships between different social systems and actors continue to sort themselves in an increasingly globalized economy, coexisting with growing spatial inequalities that mirror and reproduce better scrutinized structural inequalities. Future studies of inequalities must incorporate spatial sources and outcomes (808).

This theoretical lacuna, the need for a better connection between social and spatial relations, converges with another call for the development of models and visualization in the study of inequality and sociology in general. From this perspective, the present study is a response to Healy and Moody's (2014) call to develop awareness and the visual toolbox not only in the sociology of space but in sociological research as a whole. To the best of our knowledge, the current visualization of space-society relations consists of two-dimensional expressions, by means of colors on maps (Healy and Moody's, 2014: 123), giving us access to information containing two variables: for example, the geography of immigration and the immigrants' country of origin. In their article, Healy & Moody offer the example presented below (Fig. 1), which gives visual expression to the spatial spread of immigrants by country of origin.

Another form of visual representation is presented in Fig. 2, which reflects the geography of the distribution of wealth in New York City,

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[1] For example, according to the Gini Index, as of 2014 Israel was ranked fourth of all OECD countries in terms of inequality, after the United States, Turkey, and Mexico (Keeley, 2015). The index also highlights Israel's high incidence of poverty (18%) and its extremely high percentage of employees who earn minimum wage (OECD, 2016: 53–57). At the same time, the share of capital held by the public is on the rise, as are the wages of managers, reflecting the fact that in Israel, the strong are getting stronger and the weak are getting weaker.

[2] The southern Negev region reflects sharp social disparities both in comparison to the country's central region and on a regional scale. For example, 29.9% of all salaried employees in southern Israel earn minimum wage, in comparison to 18.6% in the Central District and Tel Aviv. The gap is more pronounced among women, with 38.8% in the south, 23.6% in the center, and 22.2% in Tel Aviv (Bank of Israel Report, 2014: 120).

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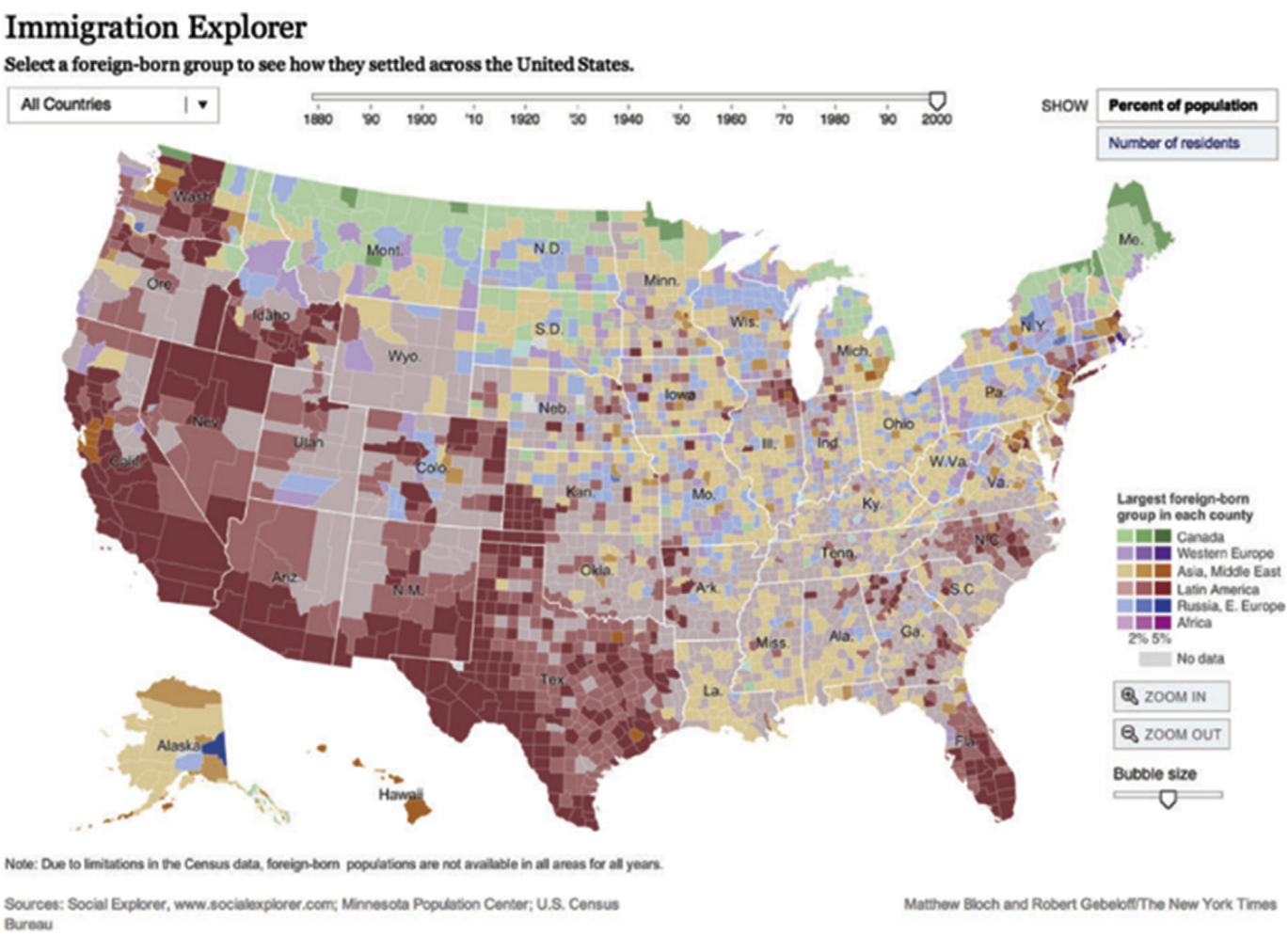

Fig. 1. Visualization of the spatial distribution of immigrants throughout the United States.

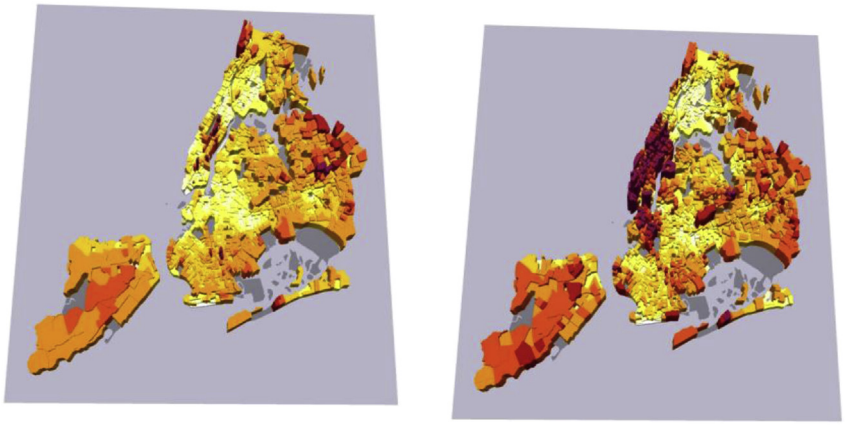

Fig. 2. Visualization of the distribution of income in New York city, 1970–2015.

but also imbues it with volume and presents an image in three-dimensions.[3]

This visualization is actually a column histogram, represented over space, which links data and space in a manner that combines familiar urban space and socioeconomic information, in this case pertaining to the distribution of wealth. This image was generated for different points in time, each of which is represented on a new map. Although this kind of visualization, as noted, links the social and the spatial, it is a visual exercise that does not constitute a model of relations of spatial inequality. Moreover, this kind of visualization continues to respond to the logic of "layers" that GIS introduced to analysis, according to which socioeconomic data can, at any time, be disconnected from urban space, leaving each realm – society and space – to continue existing in its own rite.

This research addresses the challenge of analyzing both spatial and social inequality through the development of a single, integrated model

[3] https://www.theguardian.com/cities/2017/may/17/america-geography-wealth-shrinking-urban-middle-class-visualised.

of "social topography" based on unique 3D modelling techniques that reshape space-place relations to afford a better understanding of spatial inequality. Our argument is that advanced technology in general, and the environment of virtual reality in particular, creates new opportunities to enrich our toolbox and to better meet the challenges of social and spatial integration and big data. As a result, we were able to develop a model that we can *see*, as opposed to read or talk about. Our model has visual presence, and our mode of communicating with it is visual.

The overall aims of this study are as follows:

1. To propose an innovative methodology for the study of spatial inequality on a regional scale based on a 3D visual laboratory that facilitates investigation in immersion conditions and that, we maintain, expands the toolbox of the sociology of spatial inequality. The model was developed in, and made possible by, the visual laboratory, or VizLab, of the Technion's Faculty of Architecture and Town Planning (http://vizlab.co.il), on which we elaborate below.
2. To propose social topography as a theoretical concept. After developing our "social topography" 3D modelling methodology in the virtual reality lab, a theoretical study of the term led us to the writings of two French scholars who offered the notion of social topography at different times and in different disciplines: architect and town planner Gaston Bardet (1907–1989) and sociologist Pierre Bourdieu (1930–2002). In the article, we propose a theoretical discussion that combines the theoretical projects of both (among other things): Bardet's attempt to use the concept to understand the built environment and the people in it as one integrated texture, and Bourdieu's view of sociology as a science of "social topography" that deals with hierarchies of physical and abstract spaces.

The study is therefore an attempt to contribute to both theory and methodology, and the article is structured accordingly. It begins with a discussion of its theoretical contribution – proposal of the concept of "social topography" as a conceptualization that both refines and increases the accuracy of efforts to link the social and the spatial – and continues with a discussion of its methodological contribution – use of the concept of social topography as an innovative research method that enhances our toolbox for the investigation of social inequality.

Three-dimensional social/spatial modelling based on advanced technology has been developed within different research communities, including visualization in sociology (Healy and Moody, 2014), GIS-based methodology (Crampton and Krygier, 2006) in 3-D (Hayek, 2011), smart decision making, big data (Kitchin, 2014), and smart cities (Batty, 2013). Of these, this research contributes to the field of spatial inequality within rural studies, to sociology as a whole, and to the sociology of inequality. The model was developed with regard to Israel's southern region, the Negev desert, which will serve as a primary example. However, the model is also intended for use in other places.

1. Spatial inequality on a regional scale: defining the problem

This study focuses on the subfield of rural inequalities and should therefore be considered in conjunction with the research that has been undertaken by a school of scholars who have addressed the phenomenon of spatial inequality. The study of inequality, these scholars explain, asks "who gets what and why?" (Lobao Linda et al., 2007: 1), whereas the study of spatial inequality also asks a third question: "where." This school is based on a first generation of urban and rural sociologists who have sought to advance spatialized sociology (Gans, 2002) based not on a reification of "society" or "space" but rather on an intensification of the link between the two, as well as on the work of geographers who maintain that "social relationships are space forming" (Soja, 1989).

But how can space be conceptualized by sociology? Tickamyer (2000:806) offers three possibilities: "as *place* – the particular locale or setting; as *relational units* that organize ideas about places and implicitly or explicitly compare locations; and as *scale*, or the size of the units to be compared (Lobao, 1996)." Tickamyer calls for the development and elaboration of multilevel or multiscale models (2000: 808), which "can be viewed as context, cause, or outcome for other social processes". Later in her article, she suggests that the category of space may be meaningful for the deciphering of social inequality in three ways: 1) scale; 2) comparative research; and 3) the engagement in meaning, construction, and control. The current study deals primarily with the first route and partially with the third.

In actuality, thinking about spatial inequality can and should be implemented in changing socio-spatial arenas and on changing scales. In this study, I chose to engage scale on the regional level, and in doing so to engage rural Israel – with its villages, its community settlements, and its cities, and particularly the relations among these localities. Scholars of spatial inequality argue the importance of bringing the *region* back into sociological discussion (Tickamyer, 2000: 808). Regions contain cities, rural areas, open areas, and settlements and constitute territories, such as districts, that help scholars identify the networks of divisions and power relations that structure inequality yet remain under the radar. According to Massey (1994: 265, quoted in Lobao Linda et al., 2007: 9), "some geographers argue for theorizing social relationships in space as a 'power-geometry,' 'a complex web of relations of domination and subordination, of solidarity, and co-operation'."

The decision to engage the regional scale is a response to the legacy of the 1990s, which reified three political, spatial, and social categories: the global system, the nation state, and the city (Lobao Linda et al., 2007: 4). Lobao, Hooks & Tickamyer maintain that the dominance of these categories shifted the gaze away from what was occurring in rural spaces themselves and their relations with cities. The regional scale encompasses both the rural and the urban and is of particular importance to questions of inequality, as the countryside contains locations of high social and economic value, such as mines and quarries, water sources and nature preserves, and institutions that are typically located "out there" and under the radar of scholars, such as prisons and military bases. Control over these resources is a formative foundation of regional inequality. That is to say, this is a classic example of the politics of scale (Richardson and Jensen, 2003), meaning the different ways in which social agents claim ownership and control of space through the spatial and social construction of borders. The regional scale, which captures the rural and the urban, is what Lobao et al. (2008) refer to as the missing middle subnational scale. They argue the existence of a lacuna in the sociology of inequality stemming from a disregard for the regional scale in the engagement of questions of inequality. Lobao and Saenz (2002: 502) argue that the regional scale constitutes a unique contribution of sociologists dealing with rural inequalities, which effectively link society and space and work with the concept of "territory."

According to Lobao (1996), the subfields of rural and spatial sociology is still challenged by the need to better diffuse the category of space with classical questions of sociology and, in the case in question, of inequality. Lobao calls into question the relations between society and space in the subfield of rural sociology, for example, by asking "how the principles of capitalism operate differently across space" (Lobao (1996): 89). The "new rural sociology" that emerged in the 1980s, known as the "rural restructuring" approach, shaped the rural research agenda in a new way. During this period, explains Lobao (Lobao (1996): 86), "analysts were concerned with the decline of rural manufacturing jobs and their filtering to the third world with the growth of lower wage service sectors and with rising unemployment, poverty and regional inequality." At the same time, sociologists became concerned with the growing inequalities that this economic restructuring created – inequalities that are experienced and constructed not only through socio-economic categories but also through lifestyles, attitudes, and life strategies.[4]

Lobao and Saenz (2002) draw attention to the contribution of the

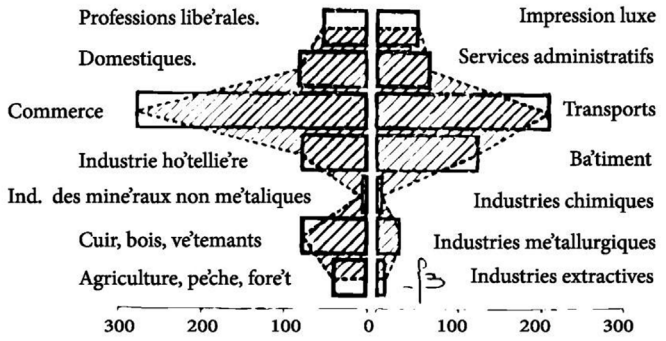

Fig. 3. A visualization of social topography according to Bardet (1951).

research that was undertaken within the field of rural inequalities on issues such as progress in production processes and industry, the encounter between development processes and the rural, the evolution of agrarian capitalism, and more. The present article presents a new methodological and theoretical platform that we refer to as social topography, which constitutes a basis for future studies. Each of the fields associated here with the field of rural inequalities constitutes an important trajectory for continued research based on the model of social topography, which is a point to which we will return in the conclusion section.

Sociological and geographical studies that interrogate Israeli society have adopted and developed the concepts of center and periphery (Tzfadia, 2012) as a means of conceptualizing the inequality that links ethnicity, class, and geographical distance. These concepts have established a foothold in Israeli academia and public discourse as an effective means of characterizing inequality in the country. Indeed, the concepts of "center" and "periphery" have constituted a basis for movements of social change, which have placed questions regarding the division of resources on the public agenda (see, for example, the land ruling of the Israeli High Court of Justice: Hananel, 2009). Other scholars have explored the labor crisis in the Israeli periphery and offer an analysis of the workers' struggle for their right to employment in the periphery (Cohen and Aharon-Gutman, 2016, 2014).

The present socio-spatial study was conducted within a technological institute that brings significant added value to the table, both because of the access to unique technological platforms it facilitates and the methodological capacities of neighboring faculties, such as Geodesy and Geoinformatics Engineering, Computer Science, and the like. We begin with a presentation of social topography as a theoretical concept whose development was inspired primarily by Bardet and Bourdieu, and we then turn to a presentation of the methodological discourse to which we seek to contribute. The third section presents the space that will constitute the case study of the article the Negev desert – Israel's southern periphery. The fourth section explains the social topography modelling method. The article concludes with a discussion highlighting the limitations and the potential of social topography for future research in the field.

2. Theory: social topography

This study makes a concrete contribution to the work of the abovementioned social inequality school by means of the concept of social topography, which enhances our ability to understand society and space as a single integrated texture.

To the best of our knowledge, the term social topography was first articulated by French planner, architect, and writer Gaston Bardet (1907–1989). Bardet (1951) contemplated how to give expression to the alchemy that occurs at the point of meeting between man and the built environment. Whether in the case of cities or rural regions, Bardet argued, this meeting point could be structured as the accumulation of people on land: "some men on land, that is to say the urban texture" (Bardet, 1951: 238). This "urban texture" – the intersection between man and the built environment – exists in villages just as it exists in metropolises. In both cases, people and the physical space surrounding them are interwoven into an integrated social topography. "I came to understand that this urban fabric was made up simply of the interweaving of human activities on the land and on the map I need to represent them," Bardet explained. "Out of this was born the principle of social topography" (Bardet, 1951: 238).

Social topography was not simply the random expression of human elements on a map; rather, it dealt with their interrelationship. Only an analysis of these elements as one assemblage, it was argued, could succeed in representing the urban texture.

Bardet also developed the concept of "sociological profile" (*profils sociogiques*), which he regarded as a tool for expressing man's movement within the maze of large social structures. Most importantly, he believed in the possibility of constructing a unique sociological profile for different localities. For Bardet, social profile was a visual expression (Fig. 3). Through the use of the images he produced, he sought to give expression to social rhythm, dynamics, and flow. Considering the means at his disposal in the mid-twentieth century, Bardet was undoubtedly ahead of his time (Bullock, 2010: 355) in his proposal of a dynamic alternative to the inflexible concepts then in use.

It is from these models that urban planning, which is always strategic, emerges. The moment that the model within which planning occurs is one of social topography, the urban planning that evolves is a direct response to the social element that "dilates with the soul of the social." The results, Bardet (1951: 355) maintains, is "a human geography created by man."

The point of meeting between French urban-social research and urban sociology was already noted in 1952 (Caplow, 1952). In an article that far preceded "global south" thinking, Caplow exposes the sociohistorical structures of the United States as the raw materials from which urban studies – as it developed in the US – was constituted. He also advocates taking an interest in the theory and methodology emerging on "other cities." Caplow observes what was being done in the field in France in order to mark the different historical-social contexts that give rise to different socio-urban theories. He views Bardet's work as particularly important and addresses his theoretical and methodological contributions. And although Caplow invites the American community to initiate comparative research as a basis for more accurate conceptualization of "the other cities," his article, as we understand it, provides the reasons why Bardet's social topography did not become a central concept in the study of cities (Bullock, 2010).

The concept of social topography did not strike roots with the scholars of its time, and scholars in recent decades have been making only minor use of it in various contexts, such as archeology (Little, 2005), psychology (Kashdan and Steger, 2006), sociology (Humphreys, 2005), and anthropology (Hindson, 1983).

In the social sciences, the concept of social topography is associated with the man who developed it in that field: Pierre Bourdieu. In an article examining Bourdieu's use of this concept, Anheier et al. (1995) highlight a fundamental premise of field theory: that social actors are located within the social realm – that is to say, within the topography of social relations that are shaped in accordance with their resources of economic, social, and cultural capital (Anheier et al., 1995, 860). In the same article, Anheier, Gerhards & Romo follow Bourdieu's lead in arguing that "sociology is a social topography" (893; Bourdieu, 1989: 16).

[4] A comprehensive research report funded by the Seventh Framework of the European Union, titled "Divercities" (2017), distinguished between multiplicity, diversity, and hyper-diversity. A major contribution of these researchers is the concept "hyper-diversity," which they define as: "A number of socio-economic, socio-demographic, and ethnic groups within a certain spatial entity, such as a city or a neighborhood … hyper-diversity refers to an intense diversification of the population, not only in socio-economic, socio-demographic and ethnic terms, but also with respect to lifestyles, attitudes and activities" (Tasan-Kok et al., 2014: 13).

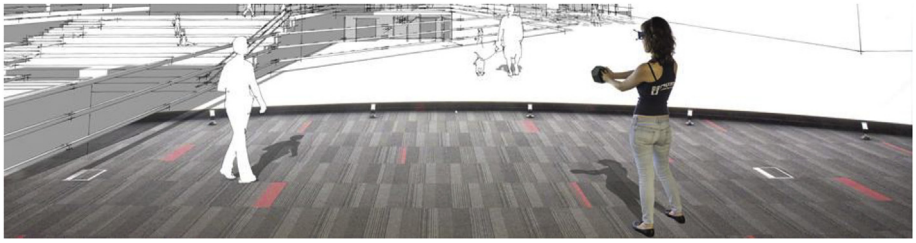

Fig. 4. VizLab at the technion.

Bourdieu's language of fields reflects a structuralist notion that conceptualizes individual dynamics within cultural and economic structures as movement within space. In this way, social structure is translated into social topography fueled primarily by segmentation and hierarchy (Anheier et al., 1995: 865).

Forms of capital undergo segmentation that does not occur on a plane but rather is hierarchal in nature, meaning that segmentation and hierarchy are linked. Just as we speak of "high culture" and "low culture," or "mainstream culture" and "marginal culture," as expressions of hierarchal segmentation (Anheier et al., 1995, 865), the same dynamic lies at the core of social topography. It occurs in fields such as culture, education, fashion, and economics, and it results in a social topography within and among all fields.

The proposed study applies this approach – drawn from imagined sociological space and institutional and organizational space – to geographical space. In doing so, it links geographical location to socio-economic hierarchy, which we refer to as inequality. In this way, it seeks to produce a model that gives spatial expression to large social structures (such as unemployment, poverty, and education), not as abstract structures, but rather in an effort to understand the correspondence between socio-economic and spatial structure. The model's dynamic nature enables us to express and study dynamics and movement, as well as the process through which hierarchal segments are produced in the course of struggles within fields. This allows us to give expression to the manner in which the outcomes of this social struggle for primacy and control in the field in question change the large structures in which people live their lives.

3. 3D modelling: a new methodology for an old problem

In addition to its theoretical contribution, this study contributes to and further develops the toolbox at the disposal of the community of scholars engaged in the exploration of society-space relations, with an emphasis on urban sociology and rural sociology, which deals with the relationship between physical and geographical space and the spectrum of social phenomena that produce space and are shaped by it.

Lobao's 1996 article considers how scholars from the field of rural sociology research society-space relations. Rural sociology, she explains, has trouble producing its own research tools, especially when it comes to questions of uneven development. For this reason, researchers have assembled tools and theories from the fields of development studies, sociology, and geography to understand what is happening in the periphery (Lobao, 1996: 98).

In this study, we propose a new form of modelling that facilitates a dynamic visual analysis of society-space relations. In this way, it differs markedly from the norm in social research today, which is based primarily on the written word and is mediated to people through reading of texts and listening to lectures. These two media require readers or listeners to paint a picture in their mind's eye. That is to say, readers and listeners must engage in a process of translation from the abstract to the concrete by transforming this picture into a visual object. This gap is entrenched in our culture and, as is frequently the case, is mediated by language. We often find ourselves asking a person who has read an article: "Were you able to see the picture that emerges from the text?" It is the picture, then, not the written word, that is perceived as the thing itself (Sontag, 1977: 91). Researchers argued long ago that seeing is a crucial sense in our human experience (Bruce et al., 1996). Realism is a powerful resource for research, and on this basis we highlight the importance of visualization in socio-spatial research. Bell (2001) asserts that "people tend to judge things on the basis of what they see as much as or more than on what they know" (quoted in Orenstein et al., 2015). On the level of research and analysis, visualization helps us "see things in ways we had not seen them before" in the sense of the accessibility of knowledge: it makes research insights accessible to increasingly wider audiences, and, in this way, it contributes to the democratization of academic knowledge (Healy and Moody, 2014). It also serves to reduce the distance between science and policy, as policy makers also "now see the picture" and can no longer remain indifferent to it.

As noted, the model was developed within the Technion's VizLab (Fig. 4), which facilitates immersion conditions and therefore also creates an experience stemming from the ability to step inside the model as opposed to simply viewing it.

The VizLab operates within a 9.2 × 6.8 m room containing a 2.4 m high curved screen with a 7 m radius and a 75° field of view, which surrounds the audience. Images are projected across the entire screen using three high-definition projectors (5740 × 1200 pixel resolution). A high-resolution camera equipped with a wide-angle lens was purchased to collect images that match projection resolution (Orenstein et al., 2015: 350). The VizLab facilitates a 3D experience in which a participant followed by tracking cameras can "move" through the image or manipulate a 3D object on the screen.

Five studies seeking to highlight the VizLab's contribution to a number of different fields have thus far been published based on research carried out in the laboratory, which facilitates immersion within future models. These fields include landscape architecture, architecture, urban design, and environmental planning (Orenstein et al., 2015; Shemesh et al., 2017; Portman et al., 2015).

One major challenge for visual studies is the challenge of interdisciplinarity. According to Portman et al. (2015), the ability to step inside planned models (or, in their words, "to go where no man has gone before") makes a decisive contribution to architecture, landscape architecture, and environmental planning. To this list, we propose adding the field of rural sociology. The breakthroughs that virtual reality (VR) facilitates for the fields of built landscape are also applicable to the analysis of socio-economic structures on a regional scale: in the social realm, as in the spatial realm, it is also possible to experience a reality that is planned or expected (Portman et al. (2015), 376). Portman et al. (2015) propose various definitions for VR, of which we chose that of Regenbrecht and Donath (1997): "… the component of communication which takes place in a computer-generated synthetic space and embeds humans as an integral part of the system …"

The emphasis of this definition lies at the heart of the theoretical and methodological challenge of researching spatial inequality: according to Regenbrecht and Donath (1997), VR has the capacity to blaze a new trail in the integrative expression of social and spatial phenomena. AR and VR, they maintain, are often studied using GIS technology (e.g., Ball et al., 2008; Bishop et al., 2001), as is the case of

the present study.

Following the example of rural studies, we made the region the focus of our study. GIS technologies are effective at representing and analyzing a wide-range of fields, and "the combination of VR and GIS facilitates exploring large regions at high resolution leading to field scale experiences with varying levels of immersion" (Portman et al., 2015: 379).

Using no more than a joystick, VizLab enables an individual to move through space and to challenge the planning and theoretical hierarchy that often stems from the definition of scale. The technological ability to move between different scales is extremely valuable for theory and basic research, as well for applied research. These issues are worthy of development in a follow-up study focusing on the contribution of advanced technologies to the development of new methods.

4. A few minutes on the negev

The Negev constitutes the southern region of the state of Israel and has a population of approximately 500,000 inhabitants. It is characterized by a desert climate (Evenari et al., 1982) and religious, national, and ethnic diversity, presenting development with unique challenges – from its physical (scale, scope, climate, and dispersal) to its ethnic diversity – that create the conditions for the emergence of acute spatial inequality, not only from the perspective of center versus periphery but also within the region itself (See Fig. 5) (see Fig. 6).

The Negev is inhabited by two fundamentally distinct populations: Jewish citizens of Israel and non-Jewish citizens of Israel, most prominently the Bedouin (to whom some scholars refer as Naqab Bedouin Arabs) (Amara et al., 2012). As the Bedouin were once a nomadic society, perceptions of space, ownership regimes, and settlement forms in the region have been diverse and subject to ongoing disagreement since the establishment of the state (Nasasra et al., 2014; Kressel et al., 1991). This fascinating aspect is central to an understanding of the Negev and has been the subject of significant research in the fields of anthropology, geography, sociology, town planning, and other areas. Within the limited framework of the present study, we follow Yiftachel's lead in emphasizing the fact that the presence of these groups throughout the Negev has resulted in different settlement forms, some that are permanent and formally recognized by the state and others that are unrecognized, whose residents are present-absentees in Israeli society and space. Yiftachel terms this phenomenon "gray space" and seeks to draw scholarly attention to the spatial and social manifestations that emerge in societies that are engaged in an ongoing struggle over land with the state. This helps explain why the major watershed of spatial inequality in the Negev is linked to the disparities between Jews and Arabs/Bedouin in the contexts of population and settlements.

For example, in a socioeconomic ranking of the settlements in Israel from 1 to 252 (with 1 being the lowest and 252 being the highest), 7 of the 9 settlements in the lowest decile are Bedouin settlements in the Negev(see Table 1).

But the Jewish citizens of Israel also do not all belong to the same socioeconomic class. The Negev contains new towns that were settled by Jewish immigrants from Asia and Africa during the 1950s, who constitute a population that is located on the margins of Israeli society and space (Haberfeld and Cohen, 2007; Lewin-Epstein and Semyonov, 1993). Over the years, the new towns ("Arei Pituach," literally translated as "development towns") that were established by the state with the aim of inhabiting frontier regions (among other things) suffered from severe problems of economic insolvency, unemployment, and ongoing dependence on government initiatives (Shachar and Lipshitz, 1981; Gradus, 1983).

Today, most of these towns are at a turning point in terms of growth, migration trends, and unemployment rates. The present day disparities are reflected in other measures, such as the percentage of minimum wage earners and the expanding labor crisis and struggles over employment stemming from the closure of the region's traditional industries (Cohen & Aharon-Gutman, 2014, 2016).

Table 2 presents data reflecting the social disparity between Jews and non-Jews and within the Jewish population, as manifested in the gaps between "development towns" on the one hand, and affluent

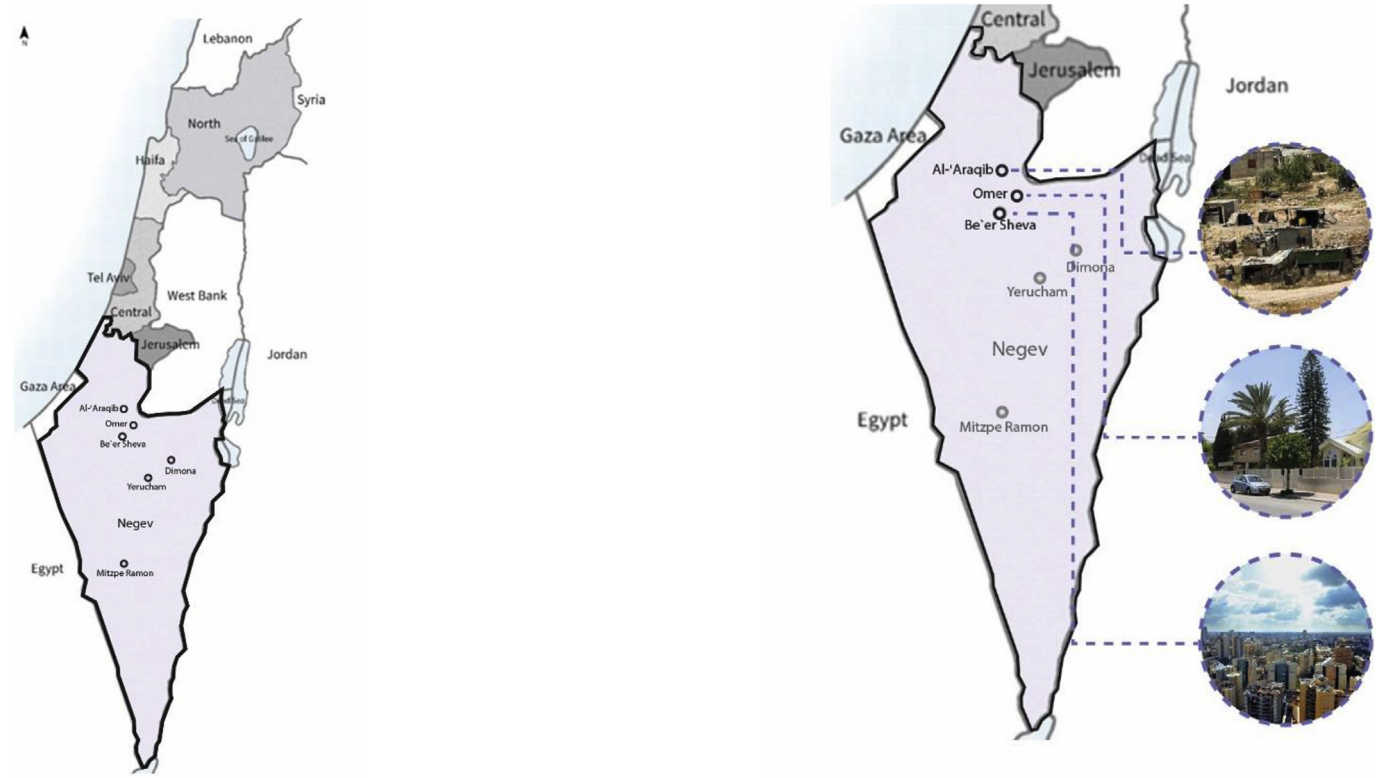

Fig. 5. The Negev and its diverse settlement.

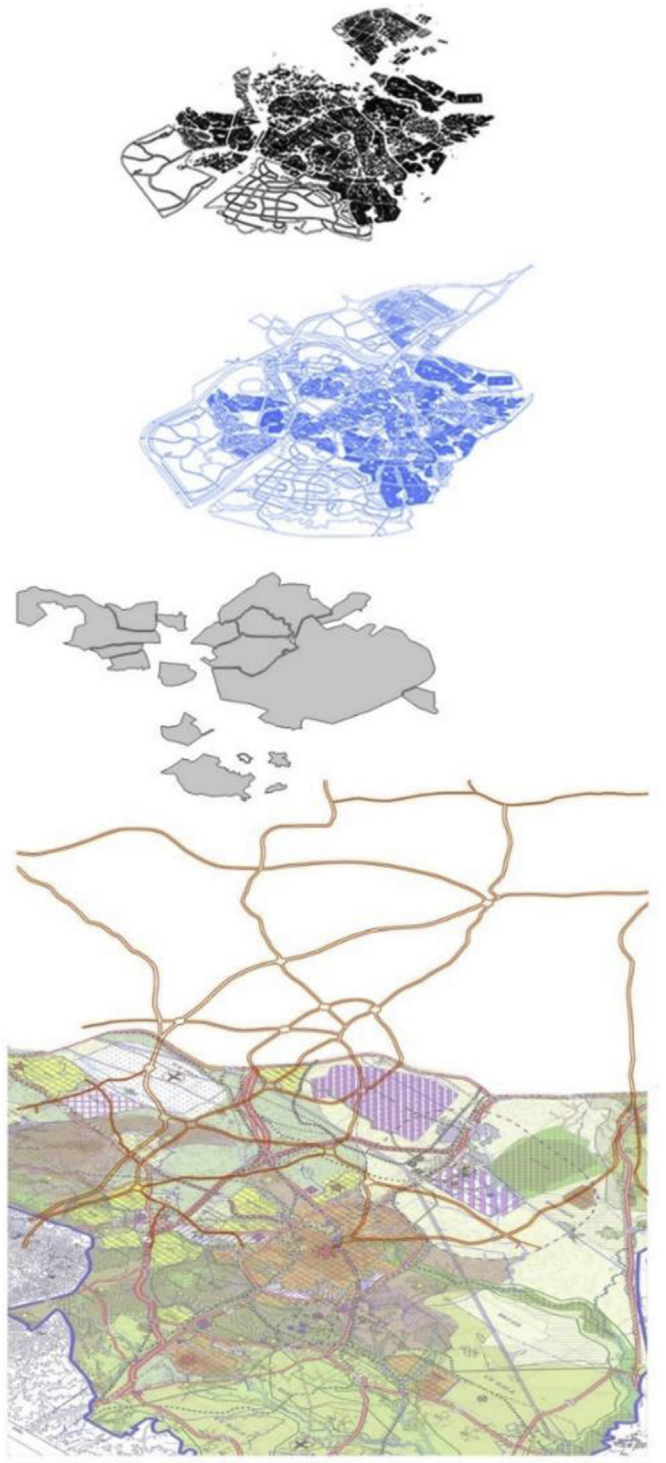

Fig. 6. The construction of a detailed statutory model – Data collection and construction by layers: metropolitan outline plan, national road network, municipal units, parcels, land uses, existing and planned building.

suburbs and regional councils on the other hand.The city of Beer-Sheva has become a home of immigrants from the former Soviet Union, who arrived in Israel in large numbers during the 1990s, and is a metropolitan area with increasingly expanding disparity (Portnov, 2002).

The Negev District, the largest of Israel's districts, is currently experiencing waves of significant development fueled, firstly, by the relocation of military bases to the Negev (Government of Israel, 2002; Aharon-Gutman, 2015; Tzfadia et al., 2010); secondly, by the implementation of a government policy of increasing the housing inventory of Israel as a whole and the Negev in particular (Israel Ministry of Finance, 2017; Mirovsky, 2015), which will result in a doubling of the population in most of the cities (Mirovsky, 2015; Tsion, 2014; Levy, 2014); and thirdly, by the advancement of investments in the high-tech sector in Beer-Sheva, the metropolitan city of the Negev (Feuer, 2015; Auerbach, 2015; Darel, 2015). These processes of development could mitigate or intensify regional inequality, and a model that generates a picture of the future of the Negev could help analyze them. This, however, is a topic for a separate study.

Table 1
Settlements in socio-economic cluster no. 1, Israel.

Settlement Character	District	Name of Local Authority
Jewish Ultra-Orthodox	Judea and Samaria	Modi'in Illit
Jewish Ultra-Orthodox	Judea and Samaria	Beitar Illit
Bedouin	South	Tel Sheva'
Bedouin	South	Kseifeh
Bedouin	South	Lakiya
Bedouin	South	Rahat
Bedouin	South	Ar'ara Banegev
Bedouin	South	Segev Shalom
Bedouin	South	Hureh

The region is also heterogeneous in terms of the localities it contains, which include a variety of different settlement types: 6 cities (Beer-Sheva, Dimona, Arad, Yeruham, Ofakim, and Mitzpe Ramon), 3 local councils (Lehavim, Meitar, and Omer), 13 Bedouin settlements (Rahat, Tel-Sheva, Lakiya, Kseifeh, Aroer, Abu Qrenat, Qasr al-Sir, Bir Hadaj, Makhul, Mulada, Hureh, Umm Batin, and Tarabin), and approximately 20 smaller Jewish agricultural settlements. The region also contains unrecognized settlements (for which we received data from the Authority for the Regulation of Bedouin Settlements in the Negev, which operates within the Ministry of Agriculture) and large areas of industrial, mining, and quarry land, nature reserve, and live-fire training areas, all of which challenge spatial continuity in the region and the ability of local authorities to develop it.

5. Base model

The area we modeled included the Beer-Sheva metropolitan area as demarcated by Regional Outline Plan (*Tamam*) 4/14/23, with a number of revisions and expansions. The study area covers 7000 square kilometers, is home to approximately half-a-million residents, and is planned to double in population in the next twenty years.

Our intention was to envision a detailed picture of the future of the region that incorporates both the present and the future. Our sources of information included primarily statutory data derived from a pool of approved plans, but also from other sources such as government decisions, open source maps, statistical databases, master guideline plans, and policy planning documents in different stages of discussion within the various planning institutions.

First, we collected the data and juxtaposed a formal statutory map of the Negev, based on an examination of 500 national, regional, city, and local detailed outline plans (see Fig. 7). This reading required distinguishing between the hierarchy and the instructions of the plans, as well as their comparison to the physical situation on the ground in the model in terms of road routes, the distribution of residences, and the different modes by which the applicable plans are actualized.

We examined national outline plans (of roads, railways, energy, nature reserves, forests, creeks and riverbeds, sewage, and textures), regional outline plans (of the Beer-Sheva metropolitan area and the IDF training campus), city plans (of Dimona, Yeruham, and Arad), and detailed local plans throughout the entire area, as well as policy documents on the national level (the establishment of new settlements in the Negev), the metropolitan level, and the city level (Beer-Sheva,

Table 2
Data on unemployment and minimum wage earners in the settlements of the Negev.

% of Salaried Employees Earning Min. Wage and below, 2014	Unemployment	Socio-Economic Ranking, 2013[a]	Total Population 2015 (thousands)	List of Settlements	
38.8	8%	136	203.6	Beer-Sheva	Beer-Sheva
40.2	15%	111	33.3	Dimona	Development Towns
42.5	7%	105	24.4	Arad	
40.6	16%	89	9.1	Yeruham	
48.0	10%	71	31.3	Netivot	
41.1	11%	112	23.1	Sderot	
51.9	43%	10	11.8	Lakiya	Arab Local Authorities
48.1	5%	9	19.1	Kseifeh	
47.5	35%	5	15.8	Ar'ara Banegev	
56.4	33%	11	62.4	Rahat	
45.5	21%	7	19.4	Hureh	
49.2	29%	2	9.1	Segev Shalom	
52.58	35%	3	18.7	Tel Sheva	
26.6	3%	253	6.4	Lehavim	Community Settlements and
21.9	2%	193	9.0	Bnei Shimon	Regional Councils
36.6	2%	135	12.8	Merhavim	
27.1	2%	157	6.9	Ramat Negev	
27.6	2%	181	7.4	Sha'ar Hanegev	
32.7	2%	165	1.4	Tamar	

[a] Between 1 and 252, with one being the lowest and 252 the highest.

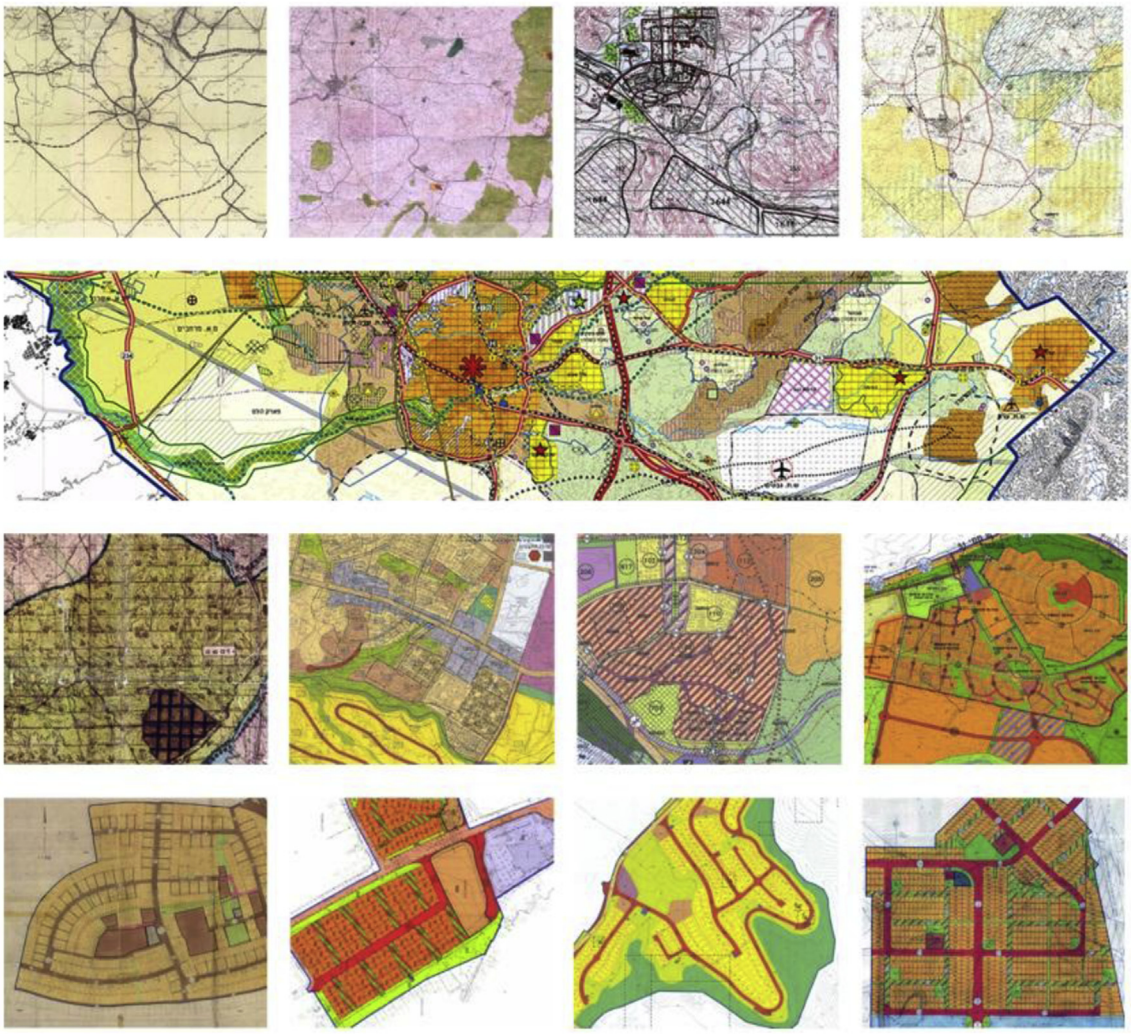

Fig. 7. Scale and scope, statutory sources of information. Top row: National outline plans; 2nd row: Regional outline plan of Beer Sheva Metropolitan Area; 3rd row: Local outline plans; 4th row: Detailed plans.

2020). We also consulted building appendices and computerized the information they contained (building, road routes and sidewalks, and recreation areas). As these elements lack statutory authority, we sought to give accurate expression to the detailed planning. We also added information we collected during the field interviews with local authority officials, as well as statistical data we collected from the Central Bureau of Statistics.

The resulting model, then, represents the planned Negev, including all components of the planning hierarchy. We strived to effect representation in as concrete a manner as possible. In other words, the model presents a detailed picture of the Negev, which also specifies policy principles and comprehensive outline planning and gives them detailed specific expression. The resulting picture revealed the array of planning intentions and the planning policy, which aims at doubling the population of the Negev within the next twenty years. For the first time, we were able to see the Negev as an integrated space and explore it by moving within the planned space on all scales – from the national scale, to the regional scale, to the city scale, to the detailed local scale. In this way, the model represented the Negev using one uniform language for all the planning levels and every database and geodatabase that was at our disposal.

The data collected was of a variety of types (vector, raster, sampling from maps, and alpha-numeric) and was georeferenced and processed in GIS environment using mostly ESRI ArcGIS for Desktop® software: ArcMap® to build the model and ArcScene® to construct the model's presentation.

6. The first attribute: 3D technology that imbues sociology with volume

Our starting point was a 3D model of the Negev that provides a picture of the future of the region based on the spatial representation of approved plans, providing invaluable insight into the future spatial conditions of the region. Fig. 8 offers a 3D representation of railways, roads, industrial areas, nature reserves, etc. The model effects integration in a multi-variable environment, the need for which Singer-Villalobos (2014) has effectively articulated by noting that "*modelling a city is a big data problem*."

By the end of the study's first year, we had produced two significant products: a social study based on descriptive statistics and qualitative research, and a 3D model of most of the Negev, including a map of its future. The most powerful finding of the social study was the immense social disparities it revealed in a variety of socio-economic categories, such as employment, unemployment, average income earners, etc. We are accustomed to viewing the disparities manifested in these categories in 2D as shown in Fig. 9.

The 2D mapping of employment (Fig. 9) is represented using two elements: geographical location and color. Notwithstanding the effectiveness of these maps (Healy and Moody, 2014), we sought a way of assimilating inequality into our physical model and considered the research value of doing so.

Fig. 10 reflects our initial results: a map consisting of spatially-grounded histograms, placed on the traditional base map which contains physical topography, buildings, and roads. We were not satisfied with this outcome, as it left us with the impression of an artificial "pasting" that advanced neither the research nor the methodology.

We asked ourselves whether we could take the radical step of integrating the social findings into our model in a way that would leave the social and the spatial inextricably bound together, as they are in reality and as Bardet suggested when he spoke of urban texture as a texture that was at once both physical and social. Our aim was to transform the social into the body of the model – the base map. In other words, we sought to convert topography into a methodology. Topography here is no longer a concept concerned with the height of objects but rather a method that facilitates the expression of hierarchies and relations of inequality over diverse realms of content. In turn, this mode of representation enabled us to re-view the concrete space through a social perspective, and to reconsider what are often neglected questions. In other words, the social topography visualized social data and embodied it within a concrete representation of space itself.

To this end, we adopted the terminology and tools offered by geodesy – which transforms heights into a "Digital Terrain Model" – and applied it to socio-economic measures according to a locality-based index. In addition, for the interval between populated areas, we defined a reference value that was used for two purposes:

1. Completion of the data to cover the entire investigated field cell, in order to enable the use of geodetic tools that apply to elevation data without leaving islands of information surrounded by areas without information.

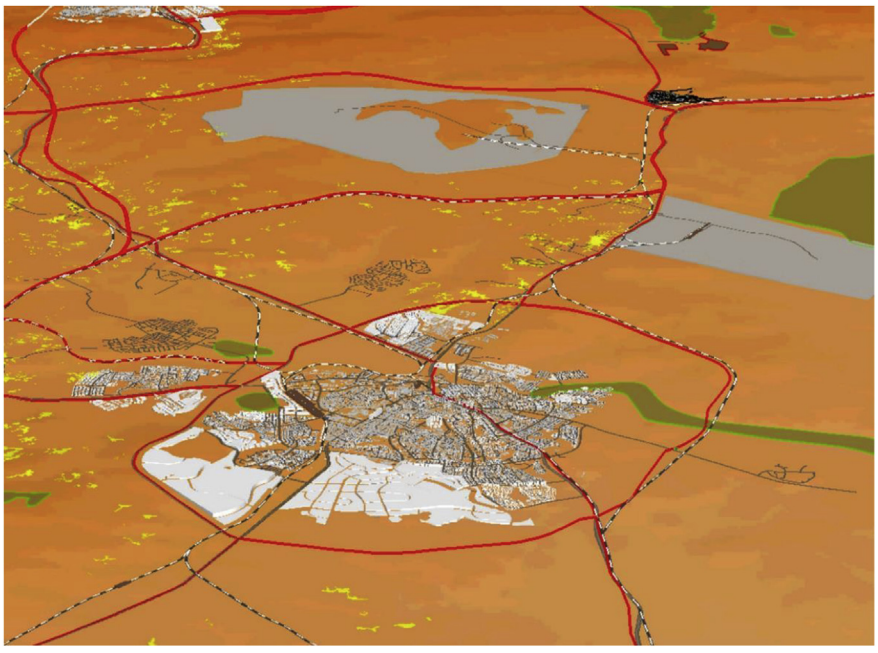

Fig. 8. A 3D regional model.

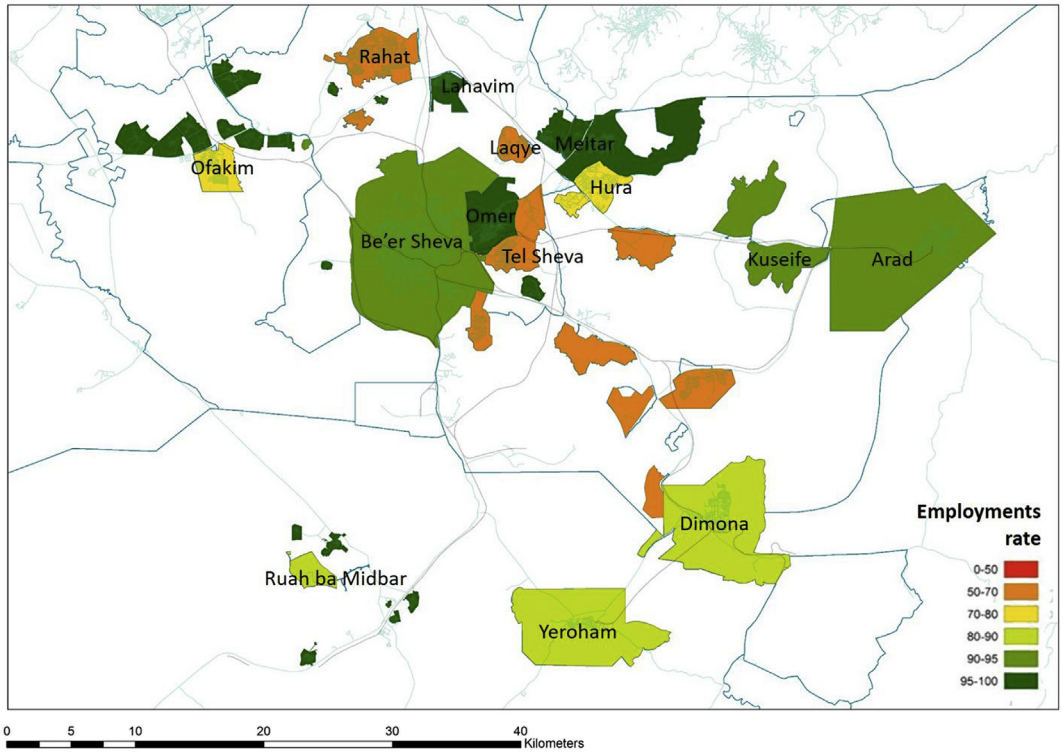

Fig. 9. A 2D sociological mapping (employment rates).

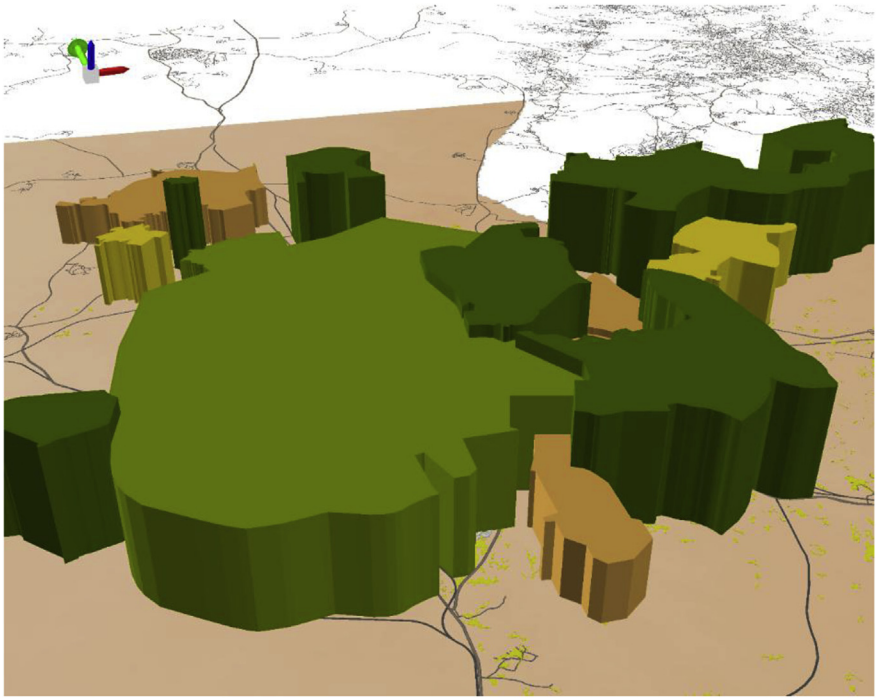

Fig. 10. A 3D visualization of inequality – an initial effort.

2. Defining a reference plane by selecting a relevant threshold value (national average income, employment threshold considered a problem, etc.) allows the viewer to see and understand, in a simple way that does not require translation, not only the gap between one inhabited area and another but also the gap between it and the relevant threshold value.

We decided to translate values that are considered positive as relatively high values, and values that are considered negative as relatively low values. Therefore, areas in which the socioeconomic value is lower than the defined threshold value appear as valleys. The model, as presented in virtual reality, allows the audience to travel along the national average level of education, climb the mountain of high income, and descend into the crater of unemployment. The results are presented in Fig. 11.

The 3D representation imbued social structures with volume and

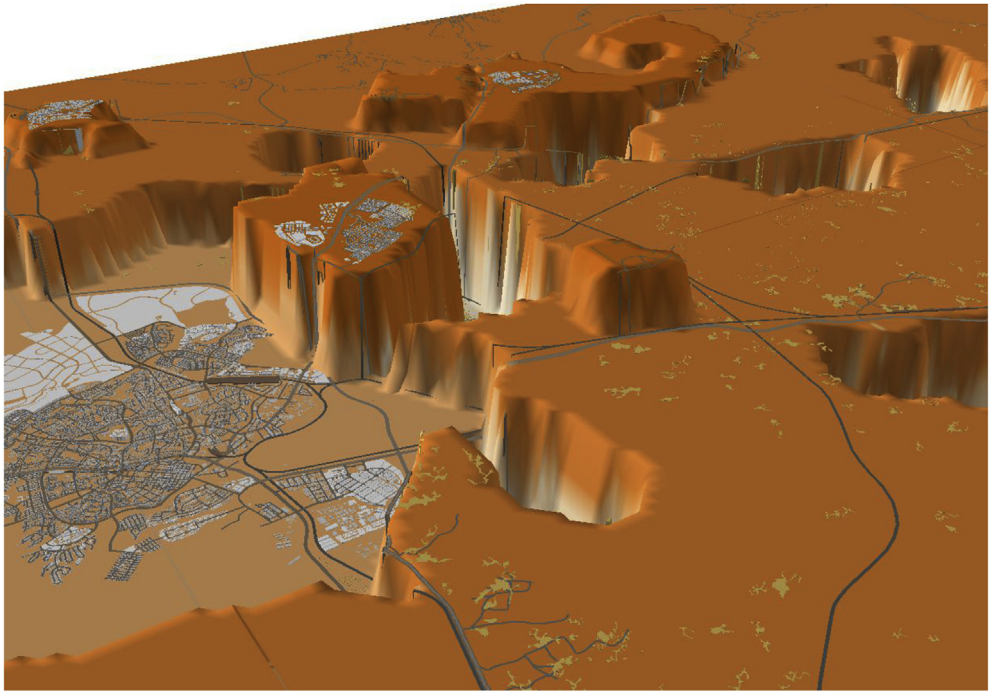

Fig. 11. Social Topography of un/employment.

produced congruence between the life experience in localities that are low on the socio-economic ladder and the modality of data representation, as reflected in Fig. 12 by the perspectives afforded by the model.

As the social topographic model is three-dimensional, the viewer is able to choose the point of view and the direction of observation. It also incorporates land cover, such as buildings and roads, into the social topography as if it were a physical topography.

Figs. 12 and 13 represent the perspective of the residents of Beer-Sheva and Tel-Sheva when they look at Omer on a sociological level. These images represent grounded visualization, meaning congruence between the quantitative and qualitative research, and this, to a great extent, is the source of its effectiveness (Knigge and Cope, 2006).

7. Conclusion: a journey into the sociology of contour lines

Our conclusion is devoted to an analysis of the significances of social topography modelling and its potential for the depiction of spatial inequality. The model's major accomplishment is its capacity to facilitate a new expression of patterns of relations, which is a central principle in rural studies due to the scale of the region and the overlap of space-place phenomena. For example, in an earlier article, Munters (1972) considers whether Max Weber can be viewed as a rural sociologist. Among his answers to this question, he explains that understanding the rural means understanding patterns of relations (Munters, 1972: 139), for which our model proposes a new analysis.

We began this article with references to the calls of scholars of spatial inequality and scholars from the field of social geography to enhance their tool boxes in light of global challenges (that have powerful implications for Israeli space) such as increasing disparities, increasing population, and crowding. These elements push us, both theoretically and methodologically, to fill out our understanding of social relations. The principles advanced by major scholars in the field pertain to: a) *place* (the particular locale or setting); b) *relational units* (that

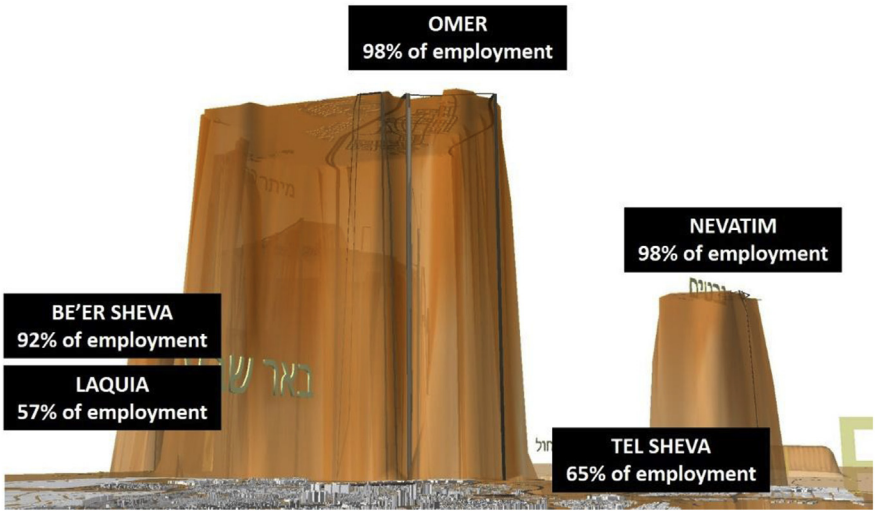

Fig. 12. Social Topography from the point of view of a resident of Beer-Sheva.

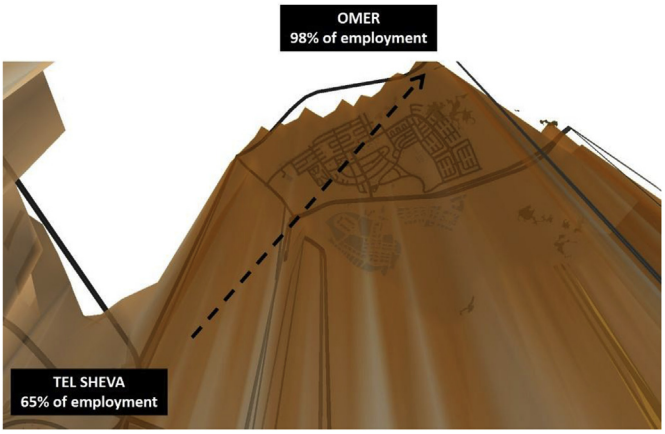

Fig. 13. Social topography from the perspective of a resident of Tel-Sheva, looking from Tel-Sheva toward Omer.

organize ideas about places and implicitly or explicitly compare locations); c) *scale* (size of the units to be compared) (Tickamyer, 2000: 806). In this conclusion, we argue that new VR technologies enable us to create places in new senses of the word (in our case, social structures that are embedded in space); to define relations between places in a new manner based on the 3D technologies that lend volume to insights that, until now, we have presented, viewed, and therefore understood only in 2D; and to challenge the scale as analytical framing due to the ability to navigate within the model and to actually move from one scale to another in a matter of seconds.

Lobao (1996) maintains that rural sociology has effectively understood the disparities in the development processes, providing it with good tools for understanding the economic crisis of the 1980s. Another advantage has been its ability to understand the manner in which the local encounters economic macro processes, stemming from the field's focus on questions of space and peripherality.

To a great extent, our study takes these two advantages one step further: by focusing on the region itself (as opposed to the city, the nation state, or the global system) as a relevant scale for research, it reveals the manner in which the local meets economic macro-processes, the disparities within the periphery, and the intensity of these disparities. This brings us to another significant contribution of social topography. Spatial inequality in Israel is often explained using the terms "center" and "periphery," and the dominance of this conceptualization has produced measures such as "the peripherality scale," which gives expression to and perpetuates the inequality between the country's center and its margins.

Social topography, however, obligates us to contend with inequality between neighboring localities that are both located in the periphery and that share common geographical conditions of geographical distance from the center, climate, etc. This issue has been addressed by scholars of spatial inequality of the past, who have distinguished between geographical periphery and social periphery (that is to say, a periphery in which other sociological categories, such as ethnicity and class, have a much greater impact on their condition). In the field of research and among decision makers, these complexities have produced strange situations in which lower-class neighborhoods located in the first or second core of the metropolitan area in the country's center have been recognized by researchers and government ministries as "peripheral neighborhoods" and allocated budgets accordingly.

The 3D analysis of spatial inequality creates a new range of space – the topography between the contour lines. This topography enables us to continue expressing geographical locations while at the same time expressing socio-economic distance, as in the case of the employment rate in each locality, which we addressed in this article. In other words, it transforms socio-economic data into structures with volume, enabling us to preserve and give expression to geographical distance (by means of horizontal space), but at the same time to use contour lines (vertical space) to express social distances.

In the theoretical section, we followed Bardet's line of thinking in his formulation of social topography. We were particularly intrigued by his attempt to think about the human and the social operating in space, and space itself, as one clustered entity, which he referred to as "urban texture." Our work is, to a great extent, an extension of these efforts. Our model represents a structural turning point in the idea of social topography in its expression of the social using social categories that produce a structure that is embedded in space itself. 3D technology and our decision to embed the sociology of inequality into the geographical realm appropriated contour lines from their geodesic monopoly and their 'objective' capacity and created a new space for sociological inquiry: a sociology of contour lines.

The concept of social topography is well suited to the general sociological imagination, which often engages questions of mobility in terms of hierarchy that individuals and groups need to climb. As shown in the theoretical section, the concept of social topography was created and cultivated by Bourdieu, among others, who engaged in the deciphering of hierarchies and argued that "sociology is a science of social topography"; or, in other words, more than it deals with flat, horizontal space, sociology is engaged in the investigation of contour lines. In this sense, we propose the investigation of contour lines as a natural field of research for sociology.

The study of contour lines holds great potential for developing an agenda for both quantitative research and qualitative research, and in the final two paragraphs, we point out future directions for developing the toolbox of rural studies in these two realms.

For quantitative research, one important achievement is the ability to represent social disparities based on statistics of major categories in the research of inequality (poverty, unemployment, education, etc.). However, the major contribution stems from our physical construction, in space, of social structures with volume. The structures produce gradients that can be measured from the moment they are created, by assessing their steepness or their shallowness. The gradient represents the relationship between social disparity and geographical distance. This new measure opens the door to new research questions that have yet to be quantitatively measured: What is the relationship between the steepness of the gradient and the academic motivation of children from the poorest locality? What is the relationship between the steepness of the gradient and crime? The model allows us to see this gradient and to quantify it, and in doing so makes an important contribution to quantitative research.

For qualitative research, people's experience of space and of the model by means of VR is well suited to new aspects of social research. The feeling of social disparity and the experience of inequality facilitated by moving within the model is consistent with the experience of life in space, as indicated in the interviews we conducted. However, unlike qualitative research, this study does not offer hierarchal space as a metaphor but rather produces true social structures viewed by people who see and experience their presence in space (as demonstrated in Figs. 12 and 13). This issue requires additional development and more in-depth research using qualitative GIF methodologies, among other methods.

This article represents the first step in a longer journey that seeks to make use of advanced technologies for the development of social topography. It proposes a sociology of contour lines, which, by means of VR technologies, shows us new modes of research that we were hitherto unable to see.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jrurstud.2018.06.010.

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