

## Groundwater in local development strategies: case of Izmir

Koray Velibeyoğlu, Hamidreza Yazdani and Alper Baba

### ABSTRACT

This study takes into account groundwater in local development strategies of Izmir, in which rapid and uneven development has occurred in recent decades. Therefore, resilience thinking is needed in the future development of the city-region. To this end, the paper aims to make an analysis of recently completed asset-based local development strategies for Izmir city towards water resiliency. The methodology has two main steps. Firstly, by using spatial interaction analysis of peninsula and river basins, potential vulnerabilities and risks are indicated. Secondly, a stratified model of strategy evaluation is conducted by scrutinizing the existing layered approaches. Then, these models were applied to all strategic decisions including water resources and indicated a high level of consistency to achieve sustainable and resilient use of blue-green infrastructure in the future of Izmir's metropolitan area. Local assets, including water resources, are the backbone of future development of the Izmir city-region. Therefore, usage of local assets in a multi-level perspective of strategy development needs to be understood. The stratified model denotes that special emphasis should be given to different river basins in different levels. This study illustrates that synergy management is needed between different layers of local development strategies, in which the role of urban and rural households is of the utmost importance.

**Key words** | groundwater, local development strategy, spatial interaction analysis, stratified approach, water resources

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### INTRODUCTION

Rural socio-economic development has gained the utmost importance in Turkish metropolitan municipalities within the frame of recent legal changes extending boundaries towards their peripheral areas. In this regard, Izmir Metropolitan Municipality (IMM) have completed a series of local development strategies aiming at the sustainable development of the city's rural hinterland. For three fertile sub-regions of Izmir, namely Peninsula, Gediz-Bakırçay and Küçük Menderes, local development strategies have been consecutively prepared.

In the framework of local development strategies, agriculture, tourism, the settlement pattern and culture, local innovation and entrepreneurship, and environmental issues

and water resources were examined as strategic themes. Among them, water, especially groundwater, has the utmost importance, since the local development of whole sectors is largely dependent on them. Therefore, local development strategies have underlined the reality of river basins and the potentials and limitations on groundwater resources due to the fact that surface waters have already been contaminated.

More than half of Izmir's water budget (nearly 60%) comes from groundwater resources. In recent years, a rapid increase in population, and uneven development in tourism and industry, has brought more pressure on these precious resources. To become more water resilient, Izmir needs to differentiate location-sensitive water strategies.

Methodologically, local development strategies have been based on the idea that rural regions are not places of isolation and deprivation; by asset-based development and creative approaches, the healthy continuum between urban and rural can be re-established. Thus, building on local assets was the main development strategy. This long-term endogenous development path was first identified, mapped and then presented within the form of local asset-based development ideas. At the first stage, description and mapping of local natural and cultural assets were determined via interactive community meetings. Then, an asset-driven database was constituted for spatial mapping of given assets. Lastly, potentially conflicting asset-based development ideas from each development theme were tested with each other and subsequently 'spatial interaction analysis' was scrutinized to understand any contrasting relations for the future development of the river basin regions.

This study aims to undertake a 'spatial interaction analysis' that elaborates potential conflicts between groundwater resources and asset-based development ideas within the frame of selected development themes such as settlement patterns, agriculture and tourism. By doing this, we scrutinize the availability of groundwater resources in selected regions, the distribution of the water budget among sectors, and the implications of the anticipated conflicts between contrasting strategy ideas. The results of spatial interaction analysis give us potential action areas bridging the conflict between selected ideas, and pave the way to find novel solutions to provide sustainability and resiliency for the important river basins of Izmir.

The approach presented in this study is important for basins that live under rapid development pressure and water scarcity at the same time. Thus, the paper seeks to find a sustainable path for local development without harming valuable groundwater resources, implying not only Izmir but also cities around Mediterranean Basin.

## OVERVIEW OF LOCAL DEVELOPMENT STRATEGIES IN IZMIR

Izmir has a surface area of 12.019 km<sup>2</sup> and a population of 4.2 million inhabitants in the western part of Turkey. The city comes in the third rank among all cities in Turkey

(Figure 1). It is well known that as a harbor city, Izmir has served as a gate to the west for Anatolia for nearly 5000 years. In the Ottoman period, the cosmopolitan population and rich trade potential of the city created a distinctive character for itself. At the turn of the last century, however, Izmir entered into a period of recession in which the reconstruction of the built environment was decelerated because of the lack of impulse that was expected to come from the national and international networks. This led to development of local strategies deriving from the different localities and capabilities of the city.

Firstly, starting from the late 1990s and especially with the impetus gained during the 2005 UNIVERSIADE, the city has started to extend its local peculiarities within the perspective of Mediterranean Basin. In 2009, Izmir Greater Metropolitan Municipality initiated a Culture Workshop that brought many creative people from various art and design fields; scientists and intellectuals from the academy and practice have become aware of the city's attempts to enhance its identity. They have started to be a part of the new vision based on (a) the city of innovation and design; (b) provision of a vision of democratic and participatory practice; and (c) improvements to the vision through cultural and ecological relationships via cities of the Mediterranean Basin (Mengi *et al.* 2017). After a while, there was apparent progress in the initiation of a number of macro-scale urban projects (such as the Izmir Sea and Izmir History projects) which are all based on the local assets and contexts of Izmir.

Secondly, another path of locality was described around the fertile ground of the city's hinterland, largely based on agriculture and tourism. Those ecologically-sensitive urban-rural fringes are under pressure from rapid urbanization and need to be protected in a sustainable way. Therefore, IMM initiated the 'Urla-Çeşme-Karaburun Peninsula Local Development Idea Competition', held in 2008. One prominent outcome of this competition was the 'İzmir Peninsula Sustainable Development Strategy' in 2013, a model of Izmir's rural development agenda that was later extended to a series of basin-based local development strategies (Gediz-Bakırçay and Küçük Menderes Basins) between 2013 and 2016 (Velibeyoğlu *et al.* 2014, 2016).

The common denominator of local development strategies is harnessing the local and regional asset base for the



**Figure 1** | Location map of Izmir Metropolitan Area.

sustainable development of the city. The principal aim is to achieve high added value products and services from all kinds of regional resources and to transform them into local benefits, taking into account the protection and low-impact development of valuable local and regional assets.

The local asset base is the key to sustainable and resilient development of cities. At the heart of asset-based development there is an idea of asset-based community development, a concept pioneered by [Kretzmann & McKnight \(1993\)](#) in the USA. This approach, rather than the traditional need-based approach (identifying community needs, deficiencies and problems), focuses on discovering a community's capacities and assets. Using asset-based development, local strategies of Izmir were explored under five

main themes: (1) agriculture, (2) tourism, (3) settlement structure and culture, (4) local innovation and entrepreneurship, and (5) water resources.

Three consecutive local development strategies have the same methodological structure, following a three step process of evaluation:

- At the first stage, a thematic and natural-cultural asset inventory was conducted according to the region's physical properties, as well as an inventory and analysis of natural and cultural assets.
- Secondly, a mapping study of natural-cultural assets was completed to discover potential clusters and areas of action by organizing community workshops, a

participatory process in which approximately 1,500 people participated in the three local river basins of Izmir. Then a strategy making process was realized by weighting and prioritizing each asset-based development idea, horizon workshop, expert panels and online Delphi questionnaire to strengthen the initial ideas. These all resulted in the preparation of the asset-driven database. A spatial interaction analysis of local assets was conducted at this stage.

- Lastly, the implementation road map, governance strategy and monitoring system were formulated.

### Water resources of the study area

The water resources of the city are very limited, and the average consumption per person is about 639 m<sup>3</sup>/year. Water scarcity is a huge problem in the long run, and its effects will be multiplied by population increase, declining groundwater resources due to thoughtless exploitation by sectors like agriculture and industry, and environmental problems

like soil salinization in coastal areas. These are the real challenges to be addressed in the near future of the city.

Water consumption of IMM has increased in recent years. The annual usable water potential of IMM is 2.63 Bm<sup>3</sup> (including 2,070 Bm<sup>3</sup> of surface water and 560 Mm<sup>3</sup> of groundwater) (Baba 2013, 2014; Murathan & Baba 2015; Murathan 2015). The province of Izmir has three hydrological basins, with the water potential of Bakırçay Basin: 36% (750 Mm<sup>3</sup>), Gediz Basin: 6% (130 Bm<sup>3</sup>) and Küçük Menderes Basin: 58% (1,190 Bm<sup>3</sup>). About 29% (161 Mm<sup>3</sup>) of groundwater is used for drinking and domestic use and 71% (399 Mm<sup>3</sup>) of groundwater resources have been used for irrigation and industrial activity in IMM. The average use of drinking water in the boundary of IMM is estimated as 200 Mm<sup>3</sup>/year (Figure 2). Generally, 35% of drinking water comes from dams and 65% is supplied from groundwater resources. According to recent data provided by the IMM General Directorate of Water Supply and Sewerage Administration (IZSU), while 60% of Izmir's water comes from groundwater resources, only 40% comes from surface waters.

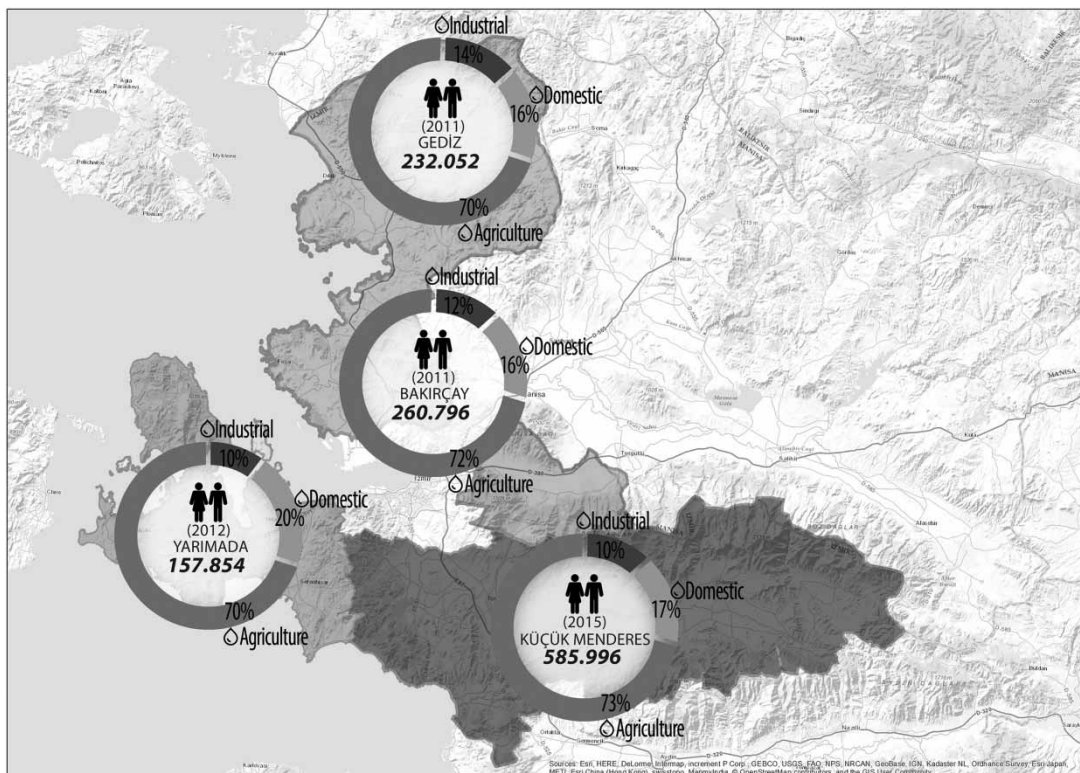


Figure 2 | Distribution of water consumption in Izmir's basins.

Groundwater is an extremely valuable and strategic precaution in agriculture as well as drinking water and industrial waters for the city. One of the most important problems of agricultural land is irrigation within the borders of IMM. Dry agriculture is being undertaken in many place because there is not enough water in a significant part of the urban agricultural land. In order to increase the economic value of these areas, building water wells is important in terms of rural development and the urban economy. For example, approximately 60,000 ha of agricultural land in the Küçük Menderes Basin, which is the most important basin of IMM, is irrigated from the groundwater.

The groundwater resources of Izmir are threatened by the consequences of climate change and human activity. Izmir is located in the Mediterranean region, which is affected by global climate change (IPCC 2007, 2013; Şen 2013). In addition, the rapid increase in population, uneven development of tourism, and industrial and agricultural activity have brought more pressure on these precious resources in recent years. For instance, Küçük Menderes has fertile soils and product diversity, and intensive agricultural activity. Groundwater sources have been used intensively for the agricultural facilities, so a drastic decline in the level of groundwater has been observed in the basin for the last 30 years (Figure 3). In addition to the wells drilled by government agencies, private wells play a major role in the over-utilization of groundwater in the basin (Sakiyan & Yazicigil 2004). It is estimated that there are more than 40,000 private wells in the plain area, only half of which are registered. These wells are mostly utilized for irrigation purposes. Unfortunately, the groundwater consumption in the basin is neither measured nor estimated on a regular basis (Yağbasan 2016).

## SPATIAL INTERACTION ANALYSIS OF GROUNDWATER

The current data on water resources clearly indicate that groundwater resources are important, and agriculturally significant river basins like Küçük Menderes need to be carefully approached in local development strategies. To keep this vital fact in mind, spatial interaction analysis is conducted for three consecutive local development strategies in order to understand the potential conflicts, risks and vulnerabilities between water and other strategic goals and preferences. To this end, conflict maps are created by applying a weighted overlay analysis in Arc GIS 10.4.1. Overlay analysis indeed applies weights to several input layers, and then combines these layers in a unique outcome layer where, according to the specification of each income layer, the suitability of the overlaid layers is evaluated. The importance or weight adopted in each layer in this study uses the results of Izmir province threshold workshops. These consecutive workshops proceed a survey on weighting 45 environmental assets of the city ranging from key biodiversity areas (highest) to marginal agricultural lands (lowest). The survey participants included a group of 30 experts in planning, architecture, agriculture biology, and many other related science fields. The results of this survey showed that protection of water resources and groundwater had higher scores according to the expert opinions (97 out of 100). Considering these variables and fixed variables for overlapping layers, the level of conflict for each sector is determined (Yazdani 2014).

Izmir Peninsula Local Development Strategy covers five metropolitan-district municipalities and constitutes 5% of

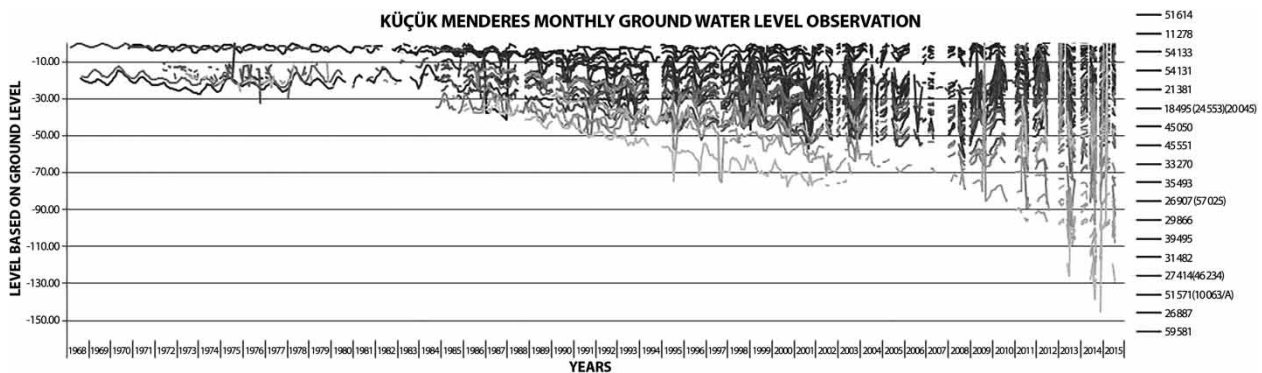


Figure 3 | Ground level changes in Küçük Menderes River Basin (Sahin et al. 2017).

Izmir's population. The basic sectors are tourism, education and recent and conflicting renewable energy investments. Water resources are scarce in the region, and there is huge development pressure from tourism and new housing development along the shorelines. Overexploitation of groundwater resources beyond their carrying capacity is the major cause of sea water intrusion problems in this region. The peninsula (especially the Karaburun part of the region) is characterized by a complex hydrogeological structure that is based on karstic formations with significant water storage in an otherwise water-scarce area. However, these resources are under severe salt water intrusion, which has significantly altered the fresh water/sea water interface as a result of excessive pumping and fault lines cutting the karstic network (Baba *et al.* 2015).

Gediz-Bakırçay Basin Local Development Strategy covers seven metropolitan-district municipalities of Izmir. The basins includes the fertile plains of Menemen and Bakırçay, feeding Izmir's population and nationwide. Basic sectors are agriculture and heavy industry (i.e. coal-powered energy plants and organized industrial zones and ports). Water resources are moderate; however, there is huge development pressure from the flourishing industry, agriculture and new housing development. Gediz and Bakırçay River Basins are agriculture-dominant; however, significant competition for water exists among various stakeholders and sectors. The decline in groundwater levels in particular has caused salinization of the coastal aquifer in the Menemen plain, located in the west of Gediz River Basin (Elci *et al.* 2015). High risk areas are indicated in red dots according to weighted overlay analysis. Physicochemical analysis of the groundwater is also added. Arsenic (As) concentrations higher than 10 ppb are detrimental to human health (DSI 2014) (Figure 4).

Izmir Küçük Menderes Basin Local Development Strategy covers eight metropolitan-district municipalities of Izmir, and by the year 2015 approximately 600,000 people were living in this region. The basic sectors are largely based on agriculture and cattle breeding. This region is known as the milk capital of Turkey. Bayındır and Ödemiş districts are also known nationwide as producers of floriculture products (i.e. cut flowers, and outdoor ornamental plants). In general, water resources are moderate; however, there is huge development pressure from the flourishing milk industry, floriculture

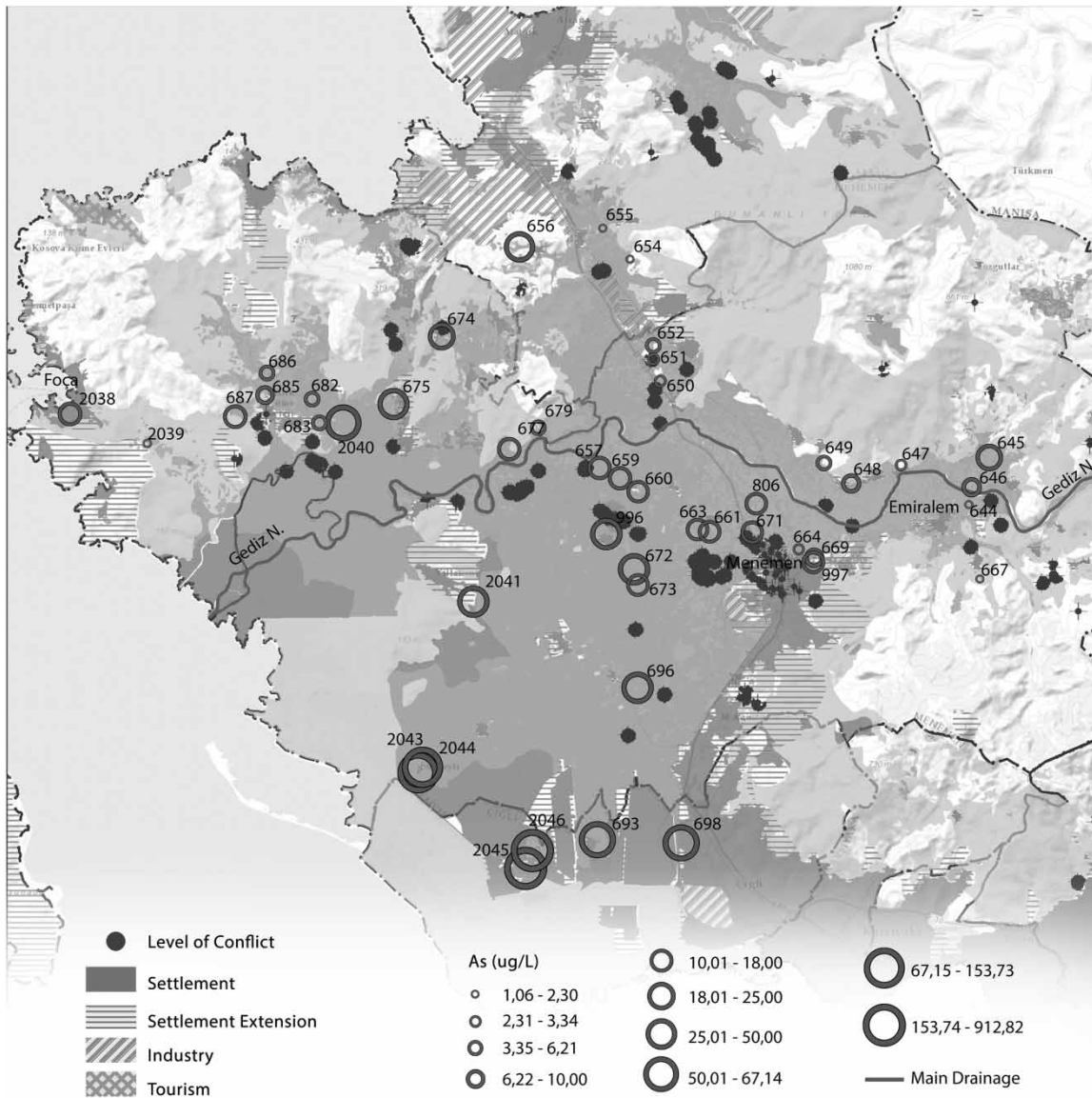
and new housing development. The large demand for drinking, irrigation and industrial water in the region of Küçük Menderes is supplied from groundwater resources. Almost every factory and cattle breeding farm has private wells that are drilled without permission. These cause the depletion of groundwater and contamination of water quality (Tayfur *et al.* 2008). Due to the overlapping of cattle breeding with intensive agriculture, groundwater is highly contaminated with infiltrating materials (Figure 5).

## STRATIFIED APPROACH TO WATER IN LOCAL DEVELOPMENT STRATEGIES

Local assets are at micro level and rooted in geographical places. Networks, on the other hand, are multi-level, and they enable us to connect assets through local, national and global interconnections. In other words, for scaling up, to create collaboration and learn from each other, local assets should meet networks of various kinds (Velibeyoğlu 2016). In local development strategies, like other themes, water is taken within a multi-level perspective (micro, meso and macro) that fits the logic of stratified models. To understand asset-network relations for each theme, Dupuy's (2008) model of 'network urbanism' is employed.

In Dupuy's scheme, there are three interrelated layers of networks. At the first level, the operators are concerned with the physical dimension of networks. These cover infrastructural networks such as water, roads, electricity, gas, telecommunications and the like. The second level deals with the operators of functional networks. These are production and consumption networks that exploit the opportunities provided by infrastructural elements at the first level. The operators at the third level resemble individuals and households using these networks via their space-time budget: 'Each level uses the level immediately below to offer services to the level above. The first two levels represent an 'objective' element in the city, while the third level has a 'subjective' character. It is at this level that individuals interpret the possibilities built in the first two levels and operate choices forming in this way their own city' (Maldonado 2005, p. 23).

Although Dupuy's model is useful to elaborate the relationship between different operators within the network, for the purposes of the study, the nature layer should be



**Figure 4** | Potential conflict between groundwater resources and developing sectors around Menemen Plain.

added at the bottom of the original model. In terms of groundwater relationships, the Dutch 'Layers Approach' is useful since it starts with a substratum level, the very nature illustrating the uneasy interplay between human and nature-based systems (Van Schaick & Klaasen 2011). Adding a geographical setting to Dupuy's model may help to locate water in a multi-level perspective. Another study, proposed by Wandl *et al.* (2012), contributes to Dupuy's model by adding geographical places as a separate level. According to the authors, geographical places are unique, relational in nature and the physical sites

of cultures and civilizations. They indicate that the nature layer (or substratum) is only used or adapted. The other two levels in the model can be managed and designed. Although household preference at the top cannot be controlled, it can be influenced by social networks and movements.

Based on Dupuy's and other stratified models mentioned above, this study takes water assets into four different levels of network operators (Figure 6):

Level zero denotes the substratum level, highly dependent on nature and geography that is used and adapted to

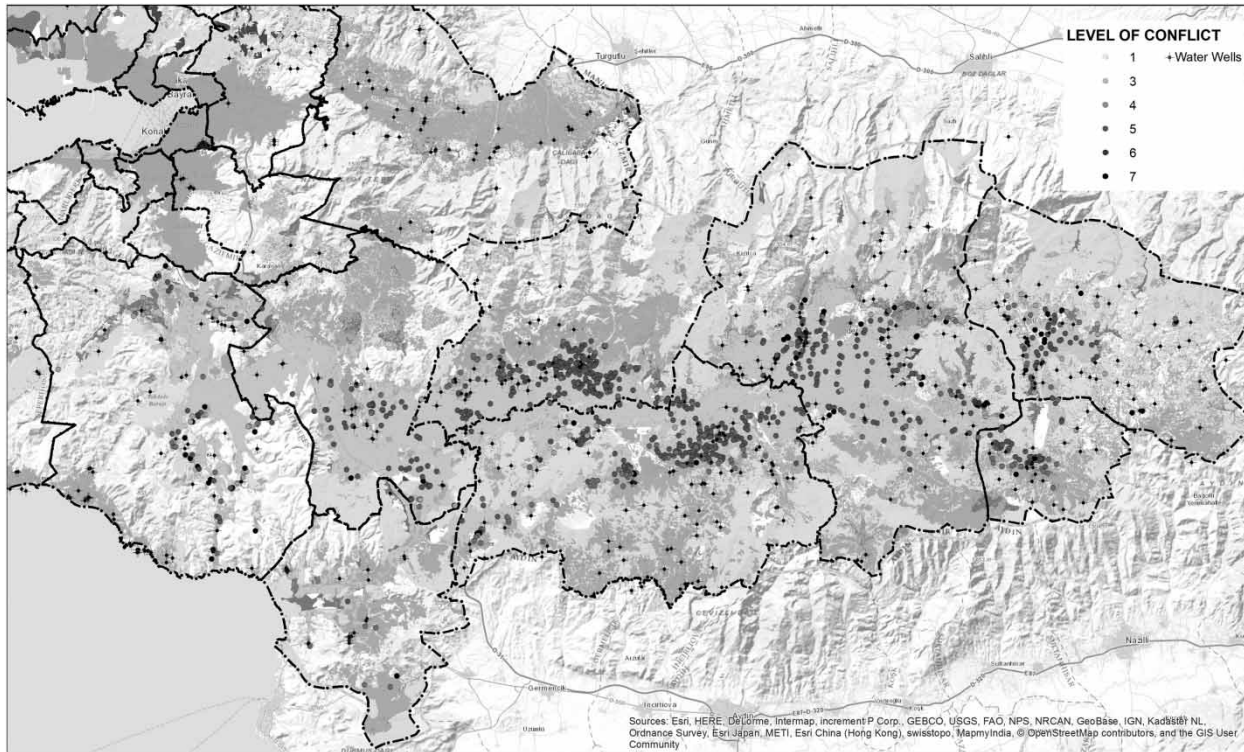


Figure 5 | Overlapping of cattle breeding areas with water wells and fertile agricultural lands.

human needs. In terms of water resources, it resembles groundwater that can be considered as a common good. In this level, use value is highly important; therefore, in local strategies, the main attitude is sustainable management and protection of these resources.

The first level states the physical network characteristics of water resources. This covers water infrastructure of all kinds from rural wastewater facilities to drinking water

systems. In local strategies, the main aim is to provide lacking water infrastructure, which is not distributed equally throughout the basins. The emphasis here is the treatment of rivers and streams that are highly contaminated by nearby domestic and industrial waste.

The second level indicates urban and rural functions consuming water resources provided by water infrastructure of the first level. In Izmir’s river basins (i.e. Küçük Menderes), agricultural use is dominant (73%) and then domestic (17%) and industrial (10%) uses follow respectively. In local strategies, therefore, the principal issue is to increase the efficiency of water use through renewable energy and urban technologies for healthy monitoring of resources. Another important point is city master plans that are responsible for allowing water-sensitive land uses wisely throughout the basins. For instance, water is scarce in the Izmir Peninsula region and there is a continuous trend for this lucrative location from service industries like tourism and education (Baba et al. 2015). Local strategies, therefore, encourage eco-tourism of all kinds by making nature and history routes and facilities.

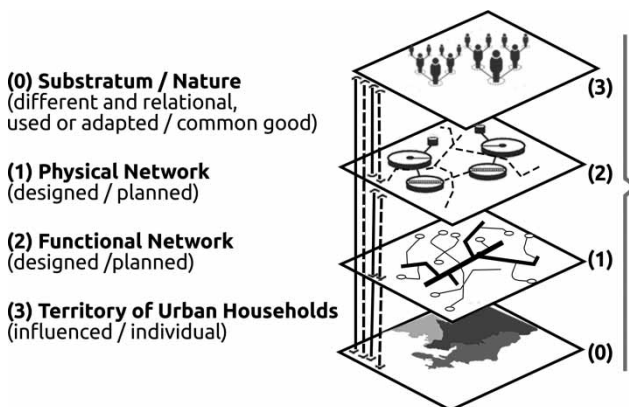


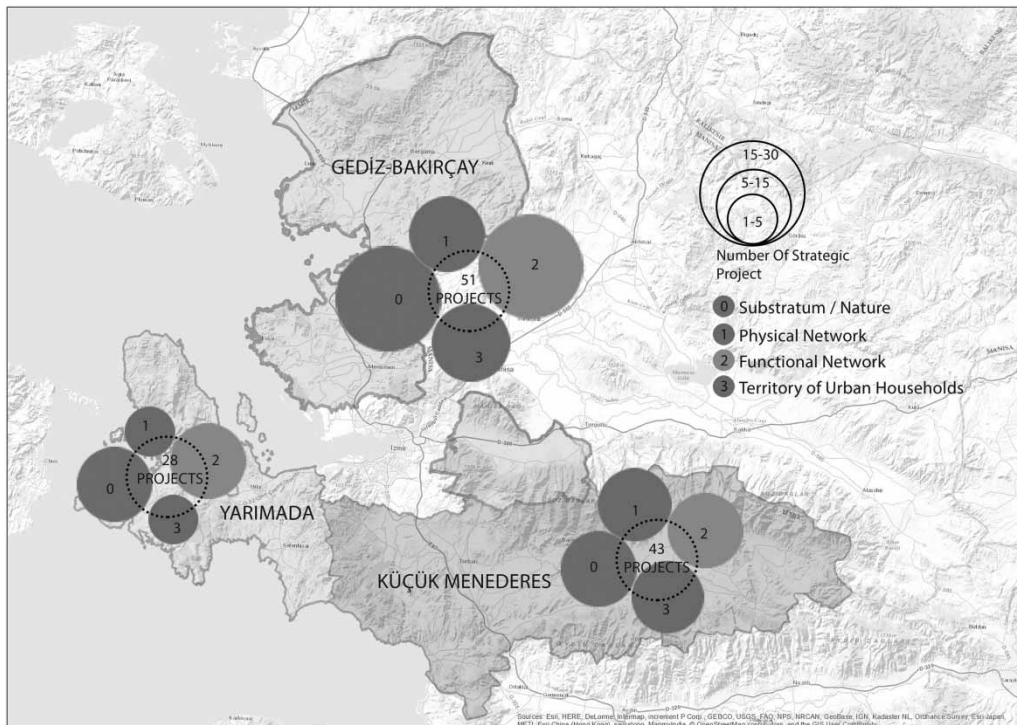
Figure 6 | Four layers of local asset-network relationships.



The third level resembles the consumption habits of urban and rural residents, which can only be influenced by campaigns and other educative and communicative tools. Globally, the first decade of the 21<sup>st</sup> century, with its deep recession, refugee crisis, hypermobile global capital, and extreme weather events, highlighted the types of ‘shocks’ that all Turkish cities including Izmir need to be able to adapt to. To become more adaptive and resilient to excessive and under-uses we harness help in resilient thinking from the responsible citizenry that is necessary for the emergence of more resilient urban ecosystems. To this end, in local development strategies, themed water and renewable energy parks and education campaigns are proposed (i.e. bio-boulevards via the EU H2020 project). At the same time, governance of water resources should be managed in a more efficient manner. For example, there are irrigation cooperatives at local level, but neither IZSU nor DSI intervene. Therefore, local development strategies give priority to governance issues regarding water actors. IZSU does not have a unit/branch for groundwater, which was

suggested via local development strategies. Similarly, the organizational capacity of irrigation cooperatives is very weak, and it is proposed that their technical infrastructure and human capacity are enhanced.

To illustrate the distribution of strategic asset-based development ideas related to water resources, a simple cross-tabulation is conducted according to the stratified model explained above (see Figure 6). This reveals that functional networks (level 2) in Izmir Peninsula and Gediz-Bakırçay Basin are mostly repeated. Izmir Peninsula region has 30 water sensitive asset-based development ideas, most of which are concentrated on the consumption network (i.e. tourism and education) and the territory of the urban household. There is an attempt to influence the decision of the urban household here via eco-tourism campaigns that impose nature-friendly and healthy living. Both Gediz-Bakırçay and Küçük Menderes Basins are agriculture-dominant; a total of 111 development ideas focus on protection of water resources and sustainable use of them through the production and consumption networks of those basins (Figure 7).



**Figure 7** | Distribution of asset-based local development ideas in water theme based on stratified model.

## CONCLUSIONS

This study focused on the role of groundwater resources in local development strategies in Izmir. The main impetus for the development of these strategies is the city's move to adapt to uneven changes to both economic and regulatory systems. Economically, as an old East Mediterranean port city, innovation and design are an utmost priority for the city. In the regulatory context, within a 10 year interval, the size of IMM has doubled due to the changes in the administrative system, with the act on the new metropolitan municipality (No. 6360) that incorporates all existing town municipalities, villages and rural territory, which were merged. Therefore, agricultural and many environmentally vulnerable and water-sensitive regions have been deeply influenced, as is clarified in the spatial interaction analysis of groundwater resources. By using a stratified model of strategy analysis, this study illustrated the efficiency of asset-based development ideas under the theme of water.

The study also revealed that there is a need for synergy management of the stratified model presented. Especially, the awareness level of urban and rural households should be enhanced within the frame of resilience thinking. Sustainable development strategies here illustrate the local endogenous development path, and a flourishing culture of governance in the making of the multi-actor, multi-level platforms. Therefore, policy learning from those cases could be helpful in further exploitation of the results towards water resiliency.

Although there have been recent strategic developments in IMM toward resiliency and sustainability of the urban-rural fringe, there needs to be an amalgamation of the results of the city-wide blue and green infrastructure strategy that creates a vital link between urban and rural areas. For instance, IZSU is working on the Water Management Master Plan of Izmir, a sectoral plan concentrating on drinking water and infrastructure issues. This plan should be aligned with the basin-based local development strategies mentioned in this study, the climate change adaptation plan of Izmir (planned to be developed till 2030) and various small to large scale local urban strategies (i.e. green infrastructure strategy) and international projects (EU, World Bank) to mitigate the hazardous impacts of climate change on water resources, for example by nature-based solutions and critical infrastructure for key industrial products.

As a result, to take advantage of this study, local authorities and researchers should concentrate on the real-time monitoring of implementations. Analysis and efficient usage of the water resources have the utmost importance. Therefore, local development strategies offer the achievement of water quality in a short period of time. In the medium term, fair distribution of groundwater among sectors and governance of the water budget is highly critical. In the long run, researchers in the field may concentrate on hydrological and hydrogeochemical models for climate change and consumption.

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