Working Paper

Public Participation GIS for Mapping Land Use Patterns in Getik Valley, Armenia

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1.Introduction

Throughout their lives, people receive benefits or services from the natural environment. These are known as ecosystem services, which are crucial for human life and well-being (Brown, 2012). However, overexploitation of them can lead to degradation (Ouko et al., 2018). We conducted a survey in Getik Valley, Armenia (Figure 1) to understand the benefits that communities receive from the natural environment, examine the distribution of ecosystem services, explore the existing relationships between ecosystem services and land use / land cover characteristics, as well as identify the problems connected to overuse of these resources. It is also important to increase the interest of local communities in biodiversity and ecosystem services conservation.

The Internet-based PPGIS system (Maptionnaire) was used to evaluate and identify ecosystem services mainly provided by forest in Getik Valley, Armenia. PPGIS is a part of broader public participation process that can use survey research methods to incorporate human–computer interaction (Brown et al., 2012). It is also a good tool for integrating public knowledge of communities, which can be used for land-use planning and decision-making (Brown, 2012), as well as environmental policymaking on the local and national levels. It is important to combine both expert and local knowledge in the decision-making process in order to achieve successful planning outcomes (Zolkafli et al., 2017).

Therefore, the questionnaire was developed using the PPGIS online tool called Maptionnarie in Getik Valley, Armenia to reveal the following information:

- land use patterns and the landscape changes in the study area,

- energy sources and demand of the local communities.

The questionnaire[1] contains open-ended questions, multiple-choice questions, as well as "draw buttons" which are questions that allow the respondent to draw a polygon or place a point, representing a certain area or spot.

This report focuses on the analysis of collected spatial data. The spatial data were collected through 16 questions using either point or polygon spatial features. In Section 2, the study area, applied methods, and results of the spatial analysis are reported. In Section 3, the overall results are discussed. In Section 4, recommendations are given.

The project is a part of the DAAD-funded collaboration GAtES[2] between the University of Hohenheim and the American University of Armenia's Acopian Center for the Environment. GAtES harnesses the ecosystem services framework and Public Participation GIS (PPGIS) methods for enhancing biodiversity conservation and sustainable development in Armenia.

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[1] https://app.maptionnaire.com/en/4732

[2] http://ace.aua.am/gates

2.Methods

2.1. Study Area

The study area of the project is Getik River Basin located in northeastern part of Lake Sevan including Chambarak consolidated municipality in Gegharkunik Region in addition to the part of the Dilijan Consolidated Municipality in Tavush Region (Figure 1). Getik Valley is situated between the mountain ranges of Miapor and Areguni, through which runs the river with the same name. The entire catchment covers an area of 581 km2. Elevation ranges in the study are between 898 m and 2985 m.
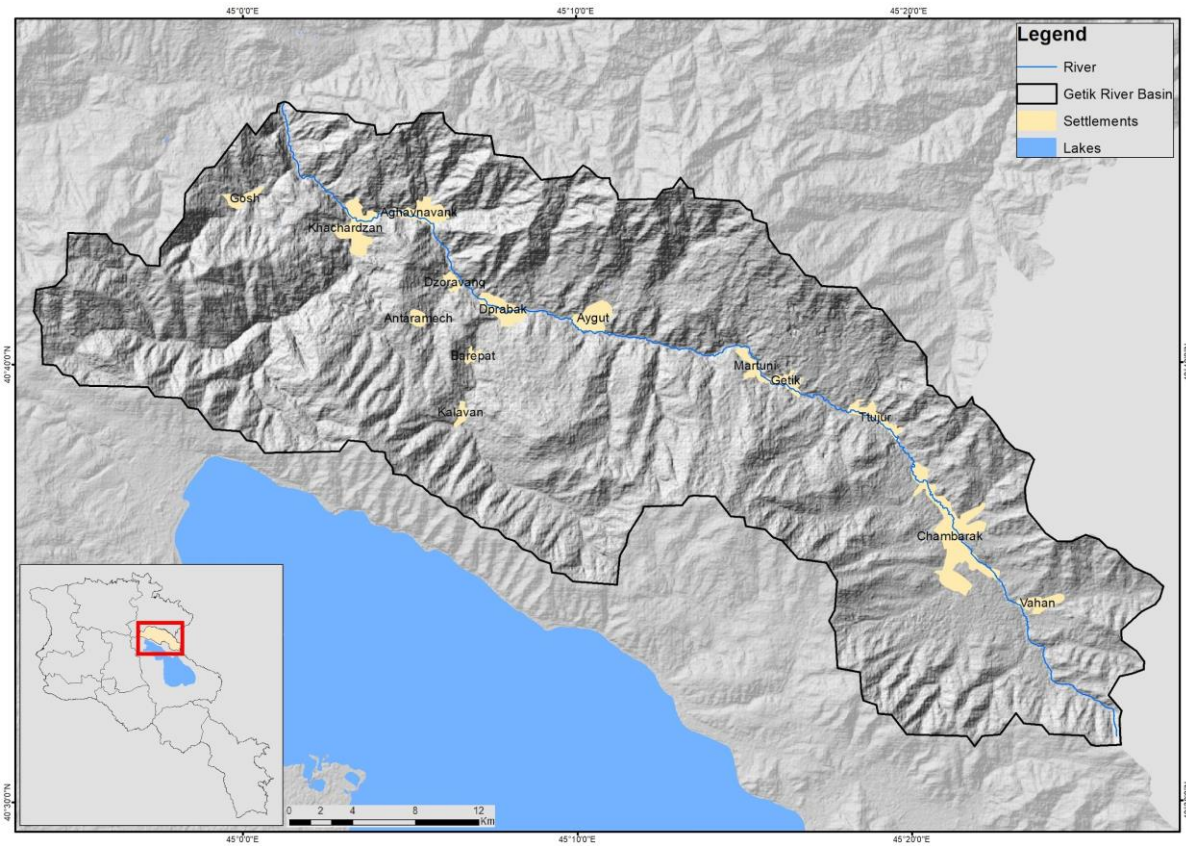

Figure 1: Location of the Getik Valley within Armenia.

Chambarak is the largest community with a population of 5,652. Overall, there are 14 settlements in the study area and the total population number is 12,549 as of January 1, 2018. Agriculture is the leading branch of economy and the main sphere of employment of population. Comparing with agriculture industry is poorly developed. More than 90% of natural forests of the Gegharkunik marz are situated in the study area. Manufacturing is the main trend of industry, and the food industry has bigger part (www.armstat.am). Getik River Basin had become one of the developing centers of rural tourism in Armenia.

2.2. Data and Methods

2.2.1. Internet-based PPGIS method

As noted earlier, an Internet-based method (in our case Maptionnaire (Mapita)) was used to conduct a participatory mapping activity. The advantages of this method are that the collected data can immediately be stored on a server, making data loss or damage less possible (Steinberg et al. 2015), and that the collected spatial (as well as non-spatial) data can be downloaded directly from the server as a GIS shapefile, which is a convenient format for further spatial analysis. Another advantage of a web-based approach is that the data can easily be shared with the community (Steinberg et al. 2015).

The interviewers used tablets to record the answers to questions (Figure 2). As slow or unreliable Internet connection could lead to significant problems, paper-based questionnaires and printed maps were prepared as backup options.

Figure 2: Survey processes using tablets

2.2.2. Basemaps of Research Area

A relevant basemap is an important part for a successful PPGIS project. An appropriate basemap should be easy to use for participants and provide sufficient detail to orient people to identify locations. It is also important to include an appropriate scale and legend for the map.

The Maptionnaire platform provides different types of basemaps. We selected two of them for our project: Roads and terrine and MapBox Satellite. These basemaps orient interviewees. The Roads and terrine map is convenient for people in finding the locations, but, unfortunately, our study area has a lack of readily available data on that map. Therefore, the MapBox Satellite map was helpful for such kinds of areas, although some part of the study area (primarily the southern part) is not visible because of cloud cover. Thus, the combination of these two basemaps was effective for the project. Also, the interviewers were trained before conducting the project in order to become familiar with the area and be able to orient the participants to relevant locations.

The paper-based map was prepared using the data available on the website of the AUA Acopian Center for the Environment[3]. The map was created at the scale of 1:150,000.

Unfortunately, we could not find any appropriate and famous landmarks located in the research area before going there. However, we collected some information about well-known places in the communities during the survey, such as the bus stop, school building, and municipality, which are specific for each village. This information can be used for further research in this area.

2.2.3. Community of Interest

The target group was the population of Getik Valley living there at least 6 months. There are 14 communities in this area, including Gosh, Khachardzan, Aghavnavank, Dzoravank, Antaramej, Dprabak, Barepat, Kalavan, Aygut, Martuni, Getik, Ttujur, Chambarak, and Vahan. Overall, 119 interviews were conducted in the regions. Although the population in these communities is not equal (for instance, Barepat has only 66 residents, whereas Gosh has 1123 residents), they were not represented proportionally in the sample. We also had several households from each community (Table 1).

Table 1: Communities of the study area, number of inhabitants and interviewees

Community	Number of inhabitants as of 01.01.2018	Number of interviewees	Region
Gosh	1,123	7	Tavush
Khachardzan	347	6	Tavush
Aghavnavank	227	9	Tavush
Dzoravank	145	9	Gegharkunik
Dprabak	584	9	Gegharkunik
Barepat	66	1	Gegharkunik
Kalavan	124	5	Gegharkunik
Aygut	913	12	Gegharkunik
Martuni	578	14	Gegharkunik
Getik	451	10	Gegharkunik
Ttujur	1,067	7	Gegharkunik
Chambarak	5,652	18	Gegharkunik
Vahan	1,113	12	Gegharkunik
Antaramej	159	0	Gegharkunik
Total	**12,549**	**119**	

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[3] http://ace.aua.am/gis-and-remote-sensing/vector-data/

The sample is not representative, but it includes several inclusive samples from each community to make sure that the questions encompass the daily life of the population in Getik Valley. The village of Antaramej is the only village which does not have any representative sample due to the inaccessibility of roads during the survey period.

The interviews took place on five different days: September 15th, 16th, 22th, 30th, and October 7th, 2018. People were interviewed either in their homes home or outside. Interestingly, the ones outside were mostly men, and one could find women at home.

2.2.4. General Topic of Research

The research project was conducted to understand how communities in the Getik Valley use land and what benefits they receive from the natural environment.

The aim of this project is to identify the intensively used areas, especially forested areas connected to illegal logging, and provide information that will help to improve and prolong the use of natural resources in the area. Another objective of the study was to identify the locations of landscape changes as a means to understand the current landscape change tendencies. For that reason, the collected data have been compared with the Land Use and Land Cover map of the Getik Valley.

To prevent illegal cutting, it is important to be aware of the land-use patterns in the affected areas and to know which role firewood plays in fulfilling the energy demand of the local communities. Therefore, a questionnaire was developed using Public Participation GIS tool Maptionnaire to reveal 1) land-use patterns, 2) landscape changes, and 3) energy use and demand of the local communities in the Getik Valley.

The results of the spatial analysis of the collected spatial data are described in the next section.

2.3. Data Analysis

The questionnaire includes 16 spatial questions (including a question about residence). 12 of them involve polygon-type data (GIS shapefiles) and four of them involve point data. After collecting the spatial data, they were downloaded from Maptionnarie as a standard Esri Shapefile. ArcGIS 10.1 was used for further processing steps such as analyzing spatial data using ArcGIS Kernel Density tool and visualization of results.

Thus, the Kernel Density tool was used to calculates the density of each dataset or spatial question in order to produce a continuous surface (ESRI Kernel Density tool[4]).

As the polygon dataset was not appropriate for analysis because of its inadequate shapes (connected to inconvenience of drawing in tablets and unfamiliarity of the residents with the maps), we converted the dataset from polygon features into points calculating the centroids of polygons.

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[4] http://pro.arcgis.com/en/pro-app/tool-reference/spatial-analyst/how-kernel-density-works.htm

The maps of each spatial question along with the spatial distribution of analysis and the descriptions are represented in the following sections.

2.3.1. Which place or landmark do you particularly value because of its historic or cultural importance?

Old churches in the Getik Valley area were mentioned by people as places of historical or cultural value. Some people value the village itself as an old place. Sometimes natural resources were mentioned as places with historical or cultural values, such as the surrounding forest or the river. Some respondents also mentioned cemeteries as important locations. Overall, 84 points were collected from the study area during the survey and the results of data analysis are shown in Figure 2.
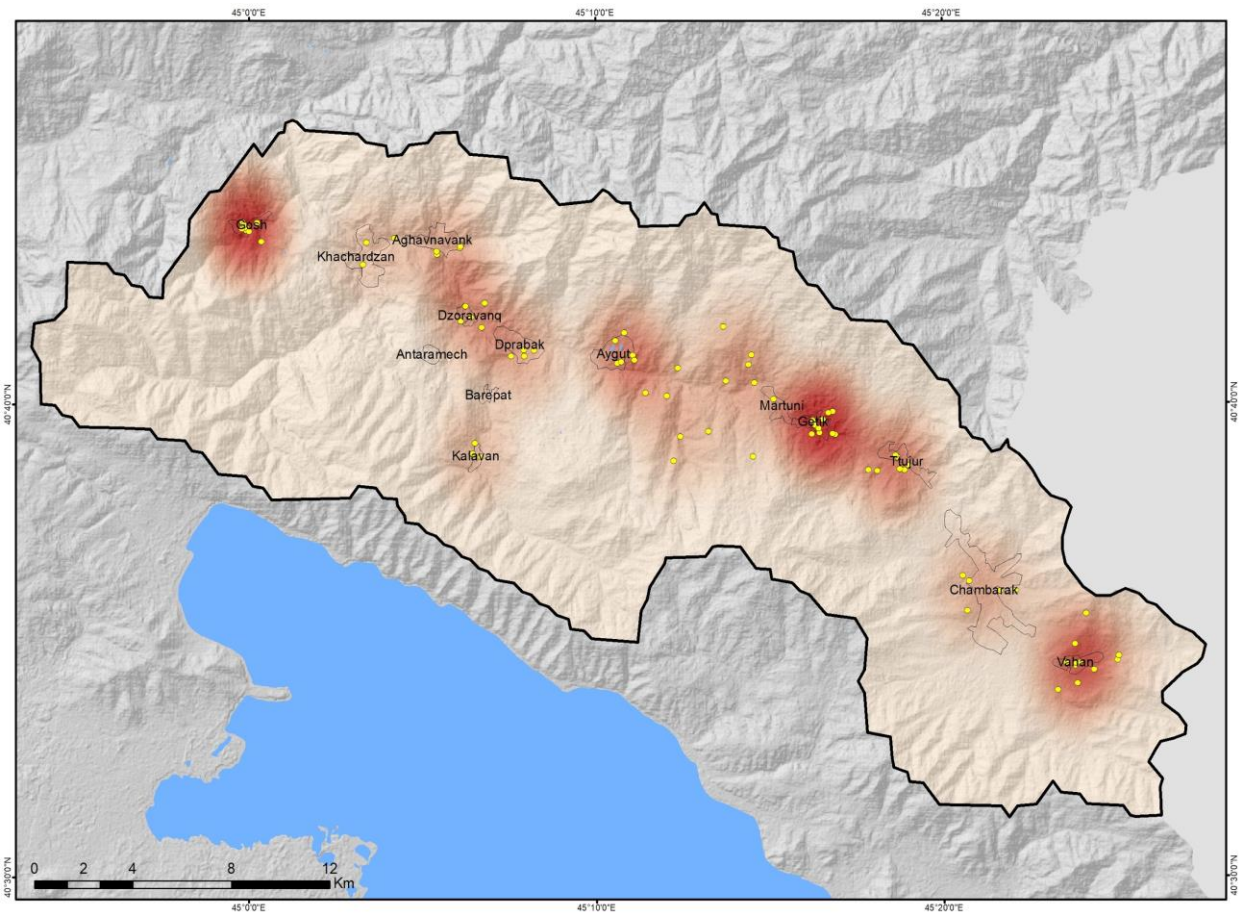

Figure 3: Spatial distribution of analysis result of historical or cultural values in the Getik Valley

The map (Figure 3) shows point distributions and generated hotspots. As we can see on the map there are a few places of clustering: first one is in the Gosh village and the second one is the surrounding area of Getik village. There is also another clustering around Vahan village.

According to the answers, there are a few famous historical or cultural places in the study area (Figure 4), such as Karmir Eghtsi (v. Martuni), Spitak Berd (v. Martuni), Destroyed bridge (v. Aygut), Goshavank (v. Gosh), Khachkar (v. Khachardzan), Cemetery and Chapel (Chambarak), Ttujur spring (v. Ttujur), etc.
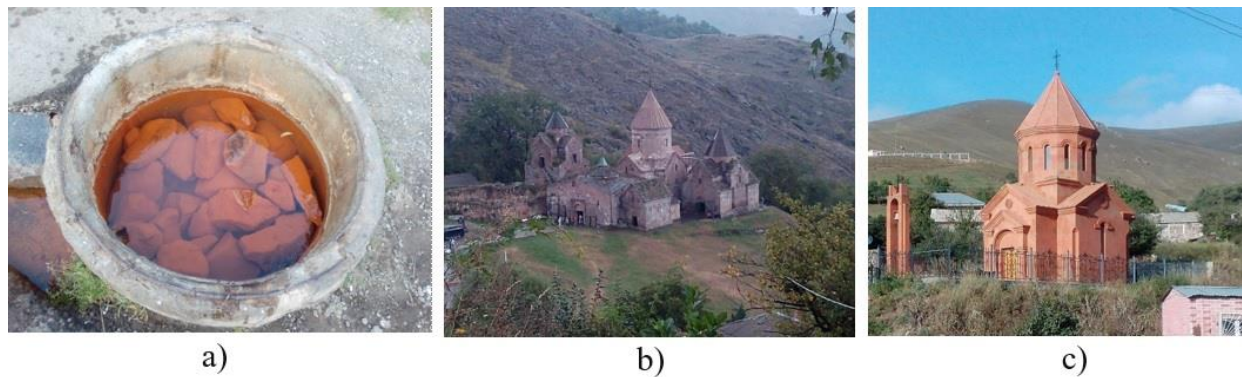
Figure 4: a) Ttujur spring in the village Ttujur, b) Goshavank in the village of Gosh, c) Monastery in the village of Ttujur

The results of collected spatial data and its combination with the notes (descriptions provided by respondents) can be used to create a map of historical or cultural places in the Getik Valley for tourism activities (Muñoz et al., 2019).

2.3.2. Where do you do beekeeping?

In total, there are 44 responses for this question. The results of the spatial analysis are shown in Figure 5. Thus, we can say that the number of the beekeepers was not very large. In fact, many of them considered it as a hobby as every villager is somehow engaged in this. In contrast to that, there were some families for whom the main source of income was selling honey. However, they complained about experiencing low sales since it is hard to sell the product locally. In the meantime, not everyone is able to transport and sell the honey in town markets.
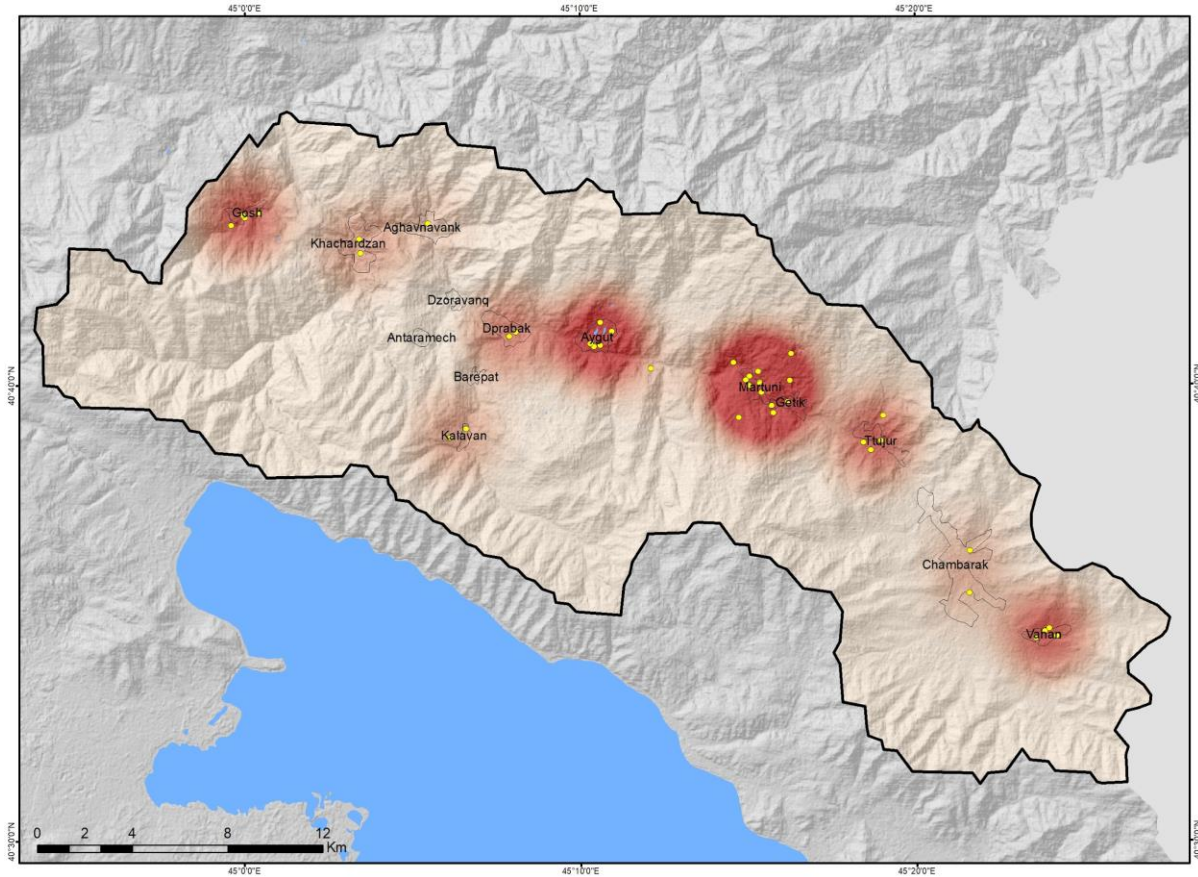
Figure 5: Spatial distribution of analysis result of beekeeping areas in the Getik Valley

As it is visible on the map (Figure 5) most of the beekeepers located the apiaries close to their houses. The reason for this, as mentioned by the locals, is that keeping the bees near the house helps to cuts many costs (e.g. transportation) and is time-efficient. One of the families in the Martuni community turned beekeeping into a tourist attraction and has a number of tourists visiting every day to see and learn the secrets of beekeeping.

2.3.3. Where do you spend time outdoors with family and friends (e.g. having a picnic)?

Interestingly enough, most of the survey participants asked to repeat this question or clarify it. Some of them thought that the question referred to going on a vacation or making barbecue.
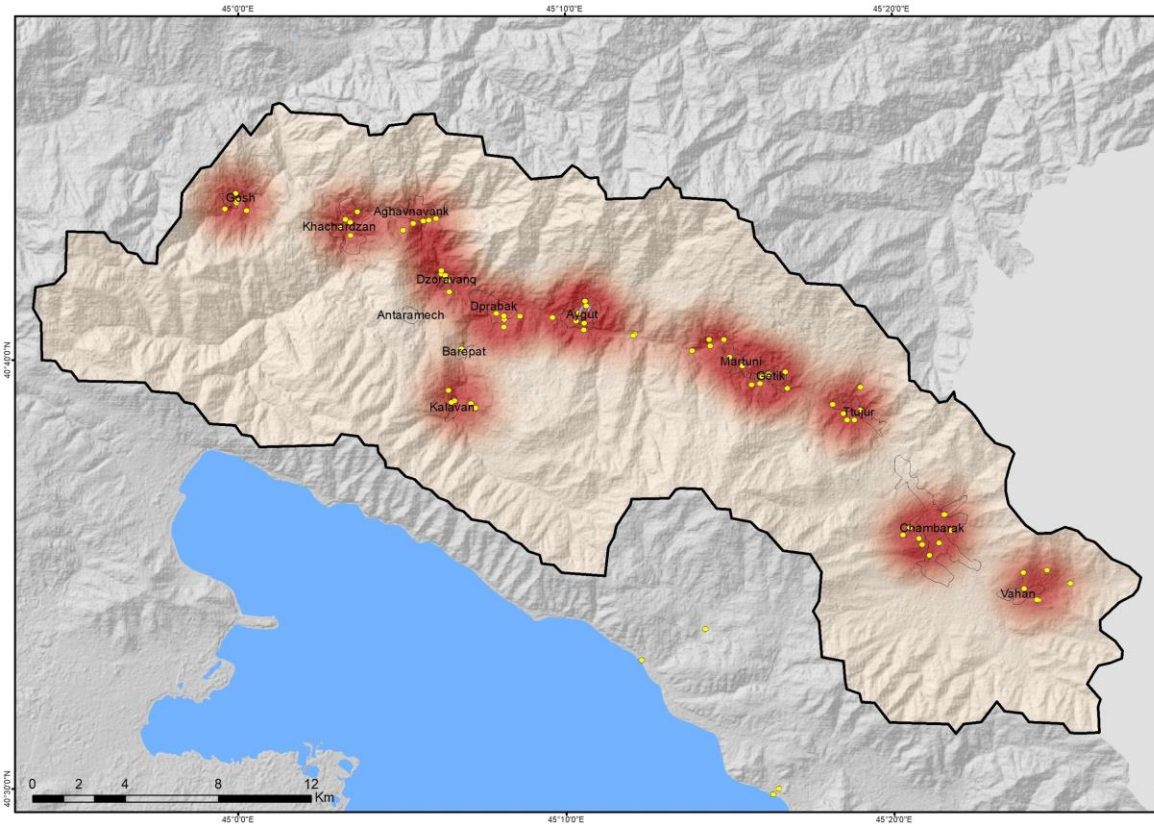
Figure 6: Spatial distribution of analysis result of time spending places in the Getik Valley

Overall, there were 82 responses and most of the responders mentioned that they do not spend enough time with their family and friends for a number of reasons, including lack of financial resources, lack of time, or negative mood. Others indicated that they organize such gatherings every day after work near their houses as shown on the map (Figure 6). Some of them mentioned that they spend time outdoors with family and friends in pavilions/gazebos, cultural sites, or on the beaches of Lake Sevan.

2.3.4. Where do you grow your fruits and vegetables?

The results of the spatial distribution of analysis (Figure 7) of this question shows that all responders (113 total) grew their fruits and vegetables near their living areas. Also, almost everyone stated that growing fruits and vegetables near their homes is the most convenient option.

For the majority of the respondents, the level of supply is not very important since they mostly grow enough fruits and vegetables to meet their own demand.

The participants consider farming as a means to meet their basic needs with minimal resources. The families that have an opportunity to transport and sell the harvest in larger communities tend to farm in more favorable locations. A few families make vodka from the harvest - some of them sell it, while others give it to their guests for free.
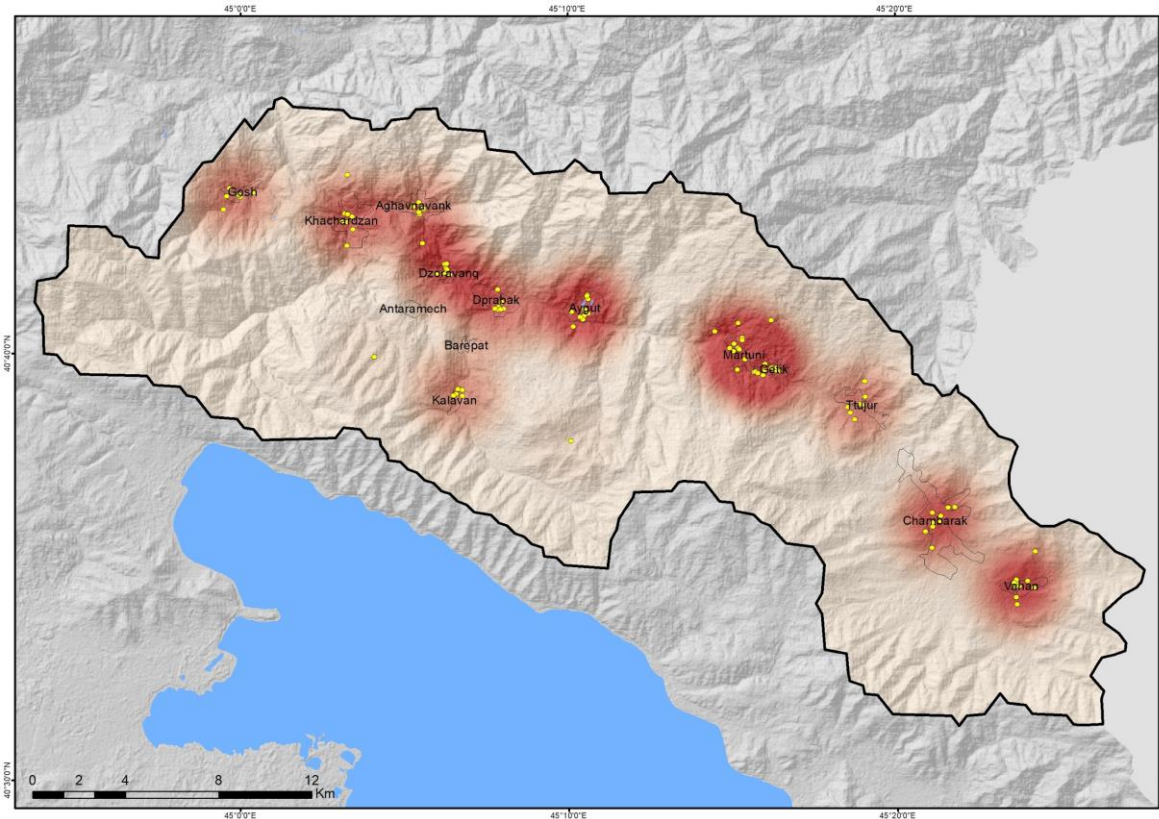
Figure 7: Spatial distribution of analysis result of fruits and vegetables growing areas in the Getik Valley

2.3.5. Where do you get your hay from?

According to the survey participants, they live in a geographical location where they do not experience any problems with hay (Figure 8). The respondents are generally satisfied with hay supplies.

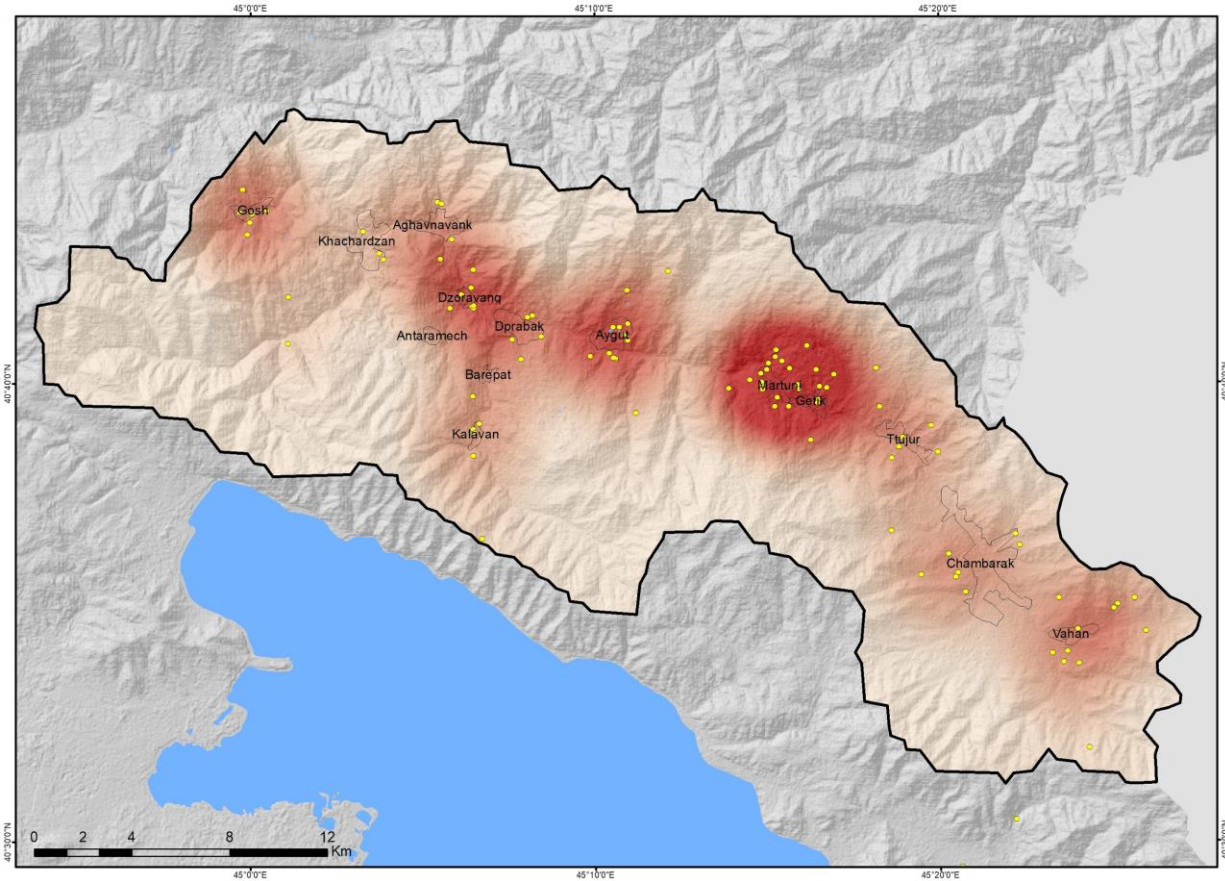However, there are complaints that in some areas there is a lack of proper machinery for compressing the hay. Consequently, the locals rent machinery that they use together.

Figure 8: Spatial distribution of analysis result of hay getting areas in the Getik Valley

Overall, there were 101 responses for this question. The result of Kernel Density analysis is shown in Figure 6. There is a strong clustering in the central part of the study area, which is connected to the spatial distribution of pastures and grasslands. The photos of this area are shown in Figure 9.

Figure 9: Pastures and grasslands

2.3.6. What area do you use for animal grazing?

Overall, there were 98 responders. According to them, there are good conditions for grazing animals in Getik Valley. The survey respondents mentioned that they are free to graze animals in areas that are not privately owned. The total area is divided among the community members and they use it in turn to graze animals.
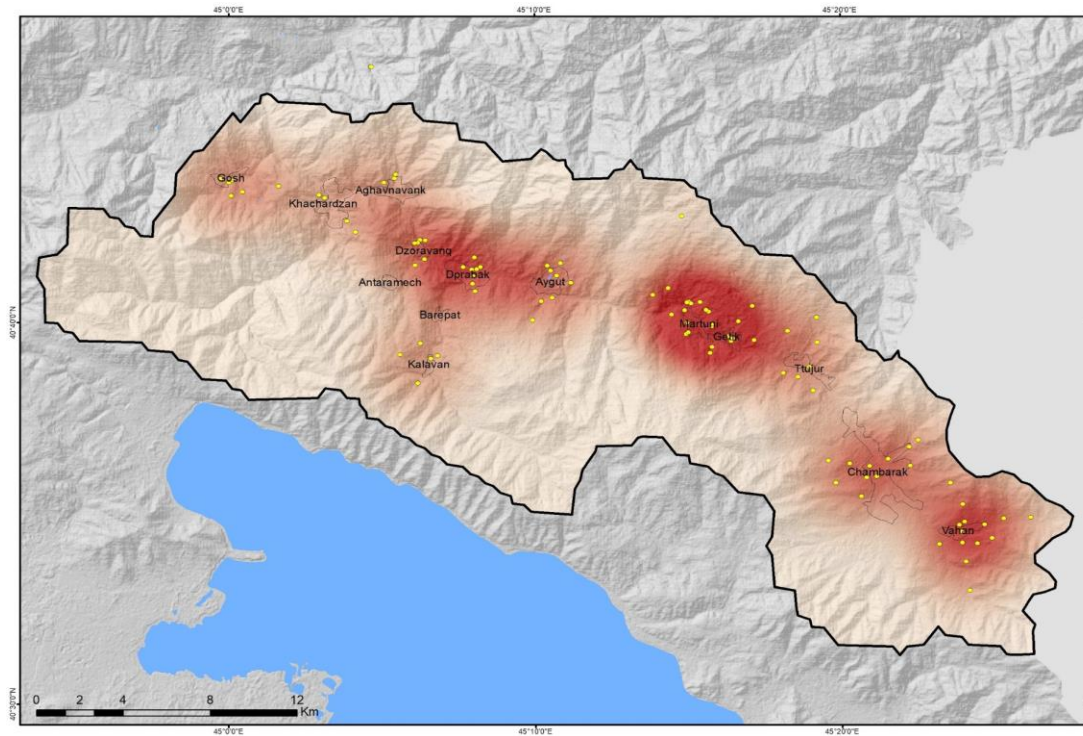

Figure 10: Spatial distribution of analysis result of animal grazing areas in the Getik Valley

The results of spatial distribution of analysis are shown in Figure 10. Since, the animal grazing areas are the same as the distribution of grasslands and pastures (basically in the central and southern parts of Getik Valley), the map highlights locations for acquiring hay.

Figure 11: Animal grazing areas

2.3.7. Where do you collect your fruits, berries, and nuts?

According to the survey participants (75 for this question), there is a large number of wild fruit trees in this region. Consequently, besides using these to meet their own needs, people are able to sell the harvest. In some areas, people make vodka out of the fruits and eventually sell it. The area is divided among people so that each of them harvests a certain amount allocated to them.

The map (Figure 12) displays areas to collect fruits, berries, and nuts, which are distributed in all the communities of Getik Valley. However, there are some clustering areas in the northern part, which is the most forested area in this region. Also, there is another clustering area in the central part.

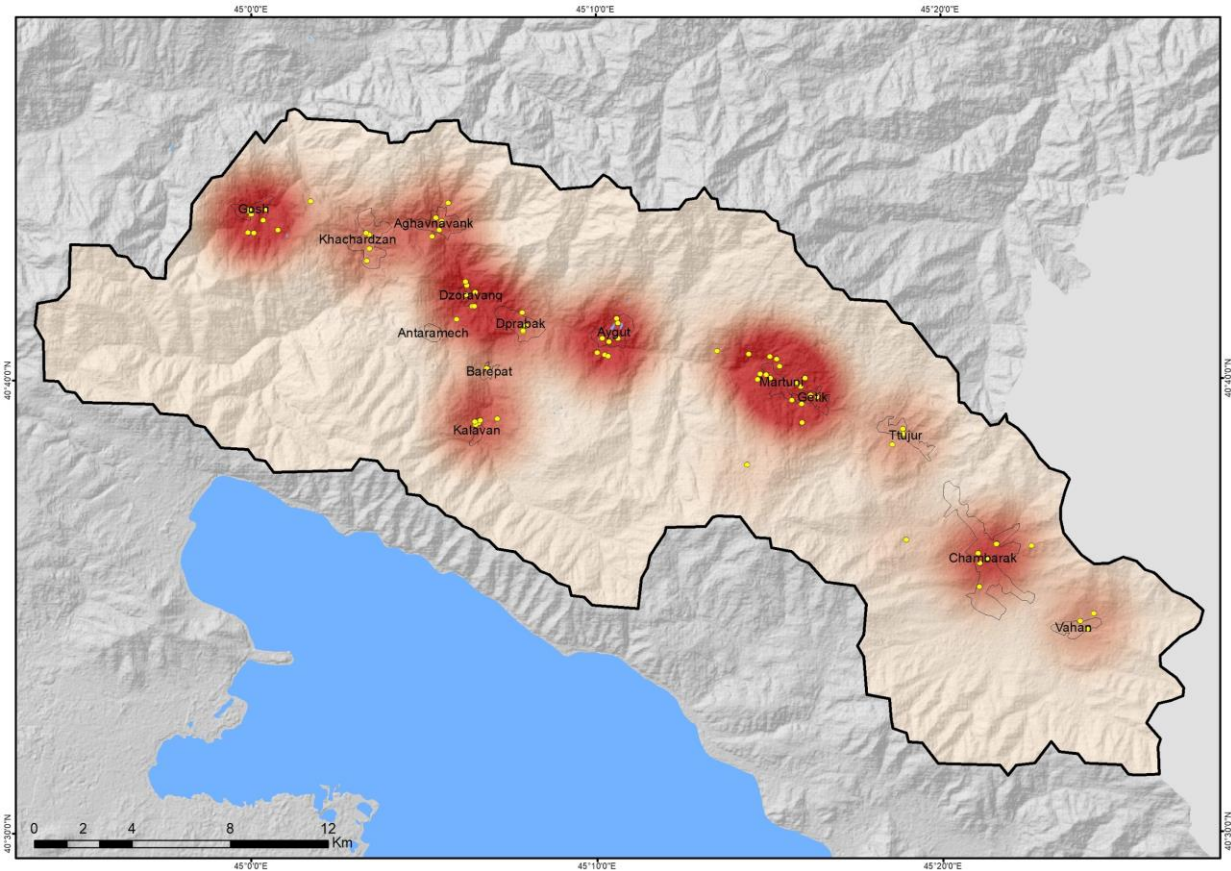Most of the wild fruit trees are growing close to the Getik River.

Figure 12: Spatial distribution of analysis result of fruits, berries, and nuts collecting areas in the Getik Valley

2.3.8. Where do you collect your mushrooms?

The survey respondents indicated that mushrooms grow everywhere in the region. They usually do not experience any other difficulty in finding or collecting mushrooms except for the unfavorable weather conditions.

There is a large variety of mushrooms growing and, in case of having appropriate conditions for storing, people can rely on mushroom sales for their living. Overall, there were 66 responses and the analysis of the results is shown in Figure 13.
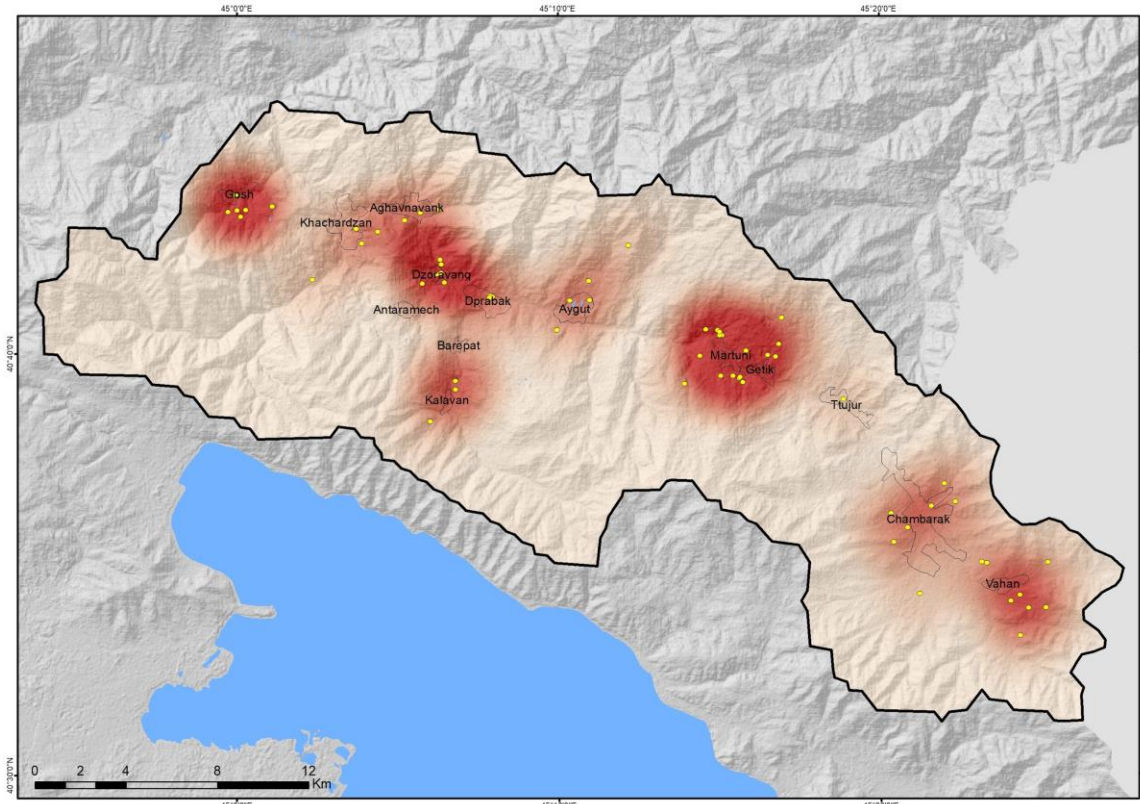

Figure 13: Spatial distribution of analysis result of mushroom collecting areas in the Getik Valley

2.3.9. Where do you collect plants for eating and medicinal purposes?

According to the survey participants (67 total answers for the question), plants for eating and medicinal purposes are distributed everywhere in the region and the participants do not have to go far from their communities to collect them (Figure 14).

Locals also prefer using herbs for medicinal purposes instead of drugs. Almost each household is engaged in herb harvesting. Some of them also sell the plants in the tourist areas, such as Goshavank. The prevailing types of herbs growing in the region are thyme, spearmint, and mint.
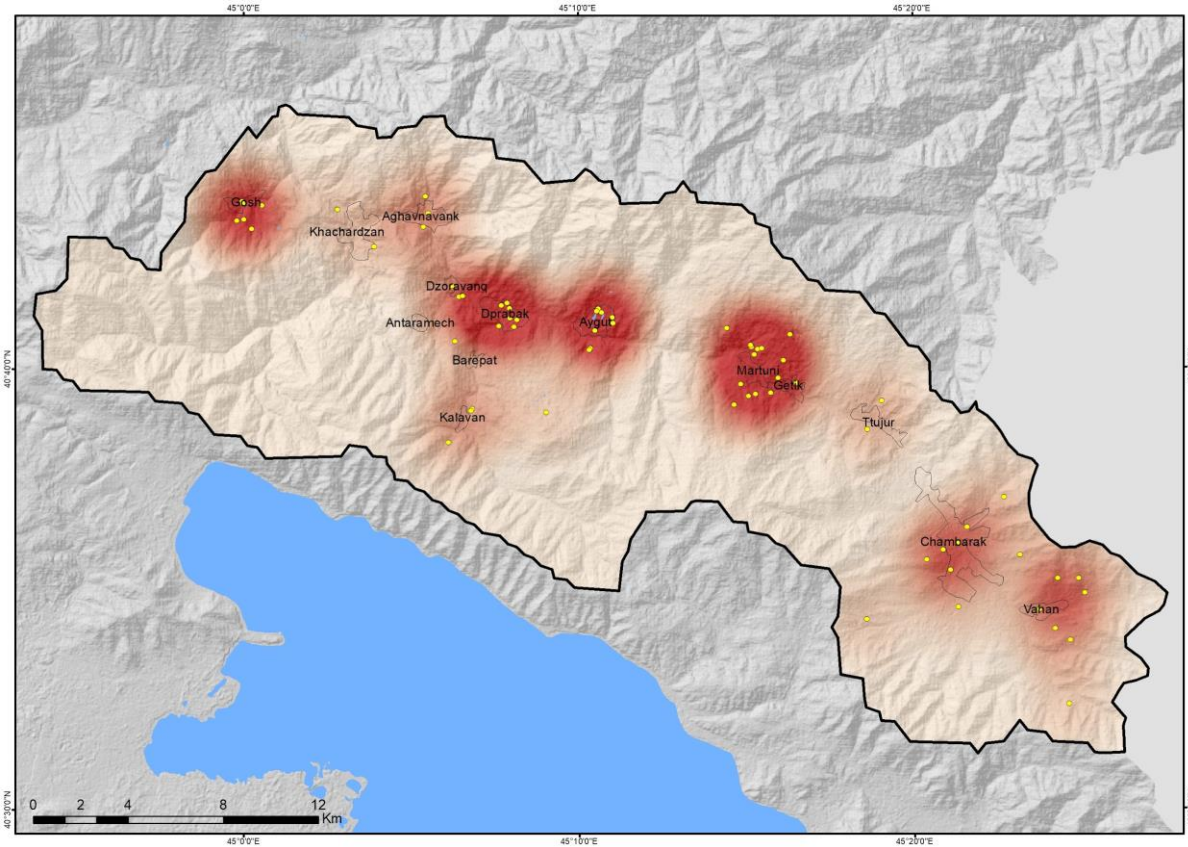
Figure 14: Spatial distribution of analysis result of eating and medicinal plants collecting areas in the Getik Valley

2.3.10. Where do you get your wood for domestic use from?

Since the region is surrounded by forests, the survey participants easily retrieve wood for domestic use from these areas. Meanwhile, authorities concerned about the removal of trees monitor the amount of cut trees to avoid exceeding a permitted level.

Some of the participants mentioned that they cut as much as it is permitted, but some of they also mentioned that they exceed the permitted level.

According to 68 respondents, the areas to retrieve wood are shown in Figure 15, which are mostly distributed in the northern and central part of the region.
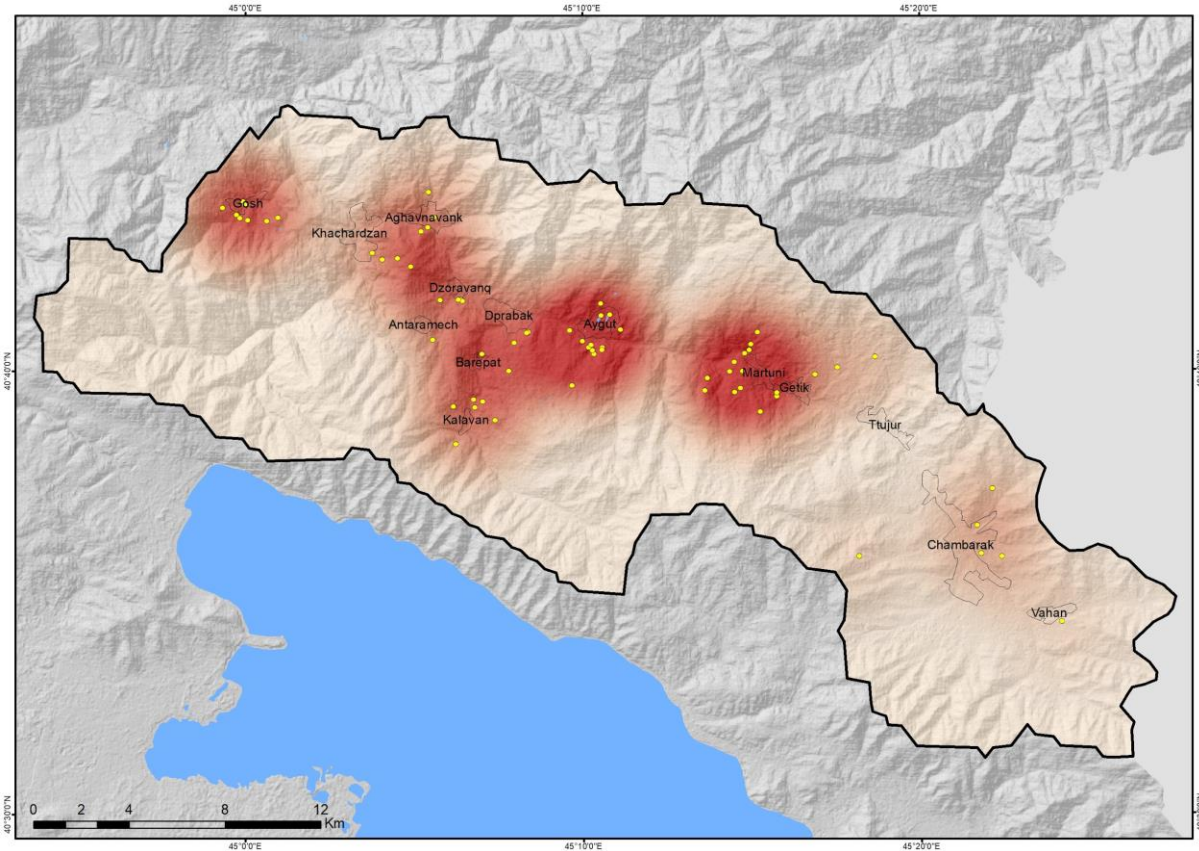
Figure 15: Spatial distribution of analysis result of wood getting areas in the Getik Valley

2.3.11. Where do you get your wild animals/game for food from?

The majority of survey respondents stated that they do not hunt and that there are no animals to hunt. Only a few mentioned that they had hunted (mainly quails, partridges and foxes).

There were only three responses for this question as most of the survey participants refused to answer. The answers are shown in Figure 16, which are located in the southern part of the study area.
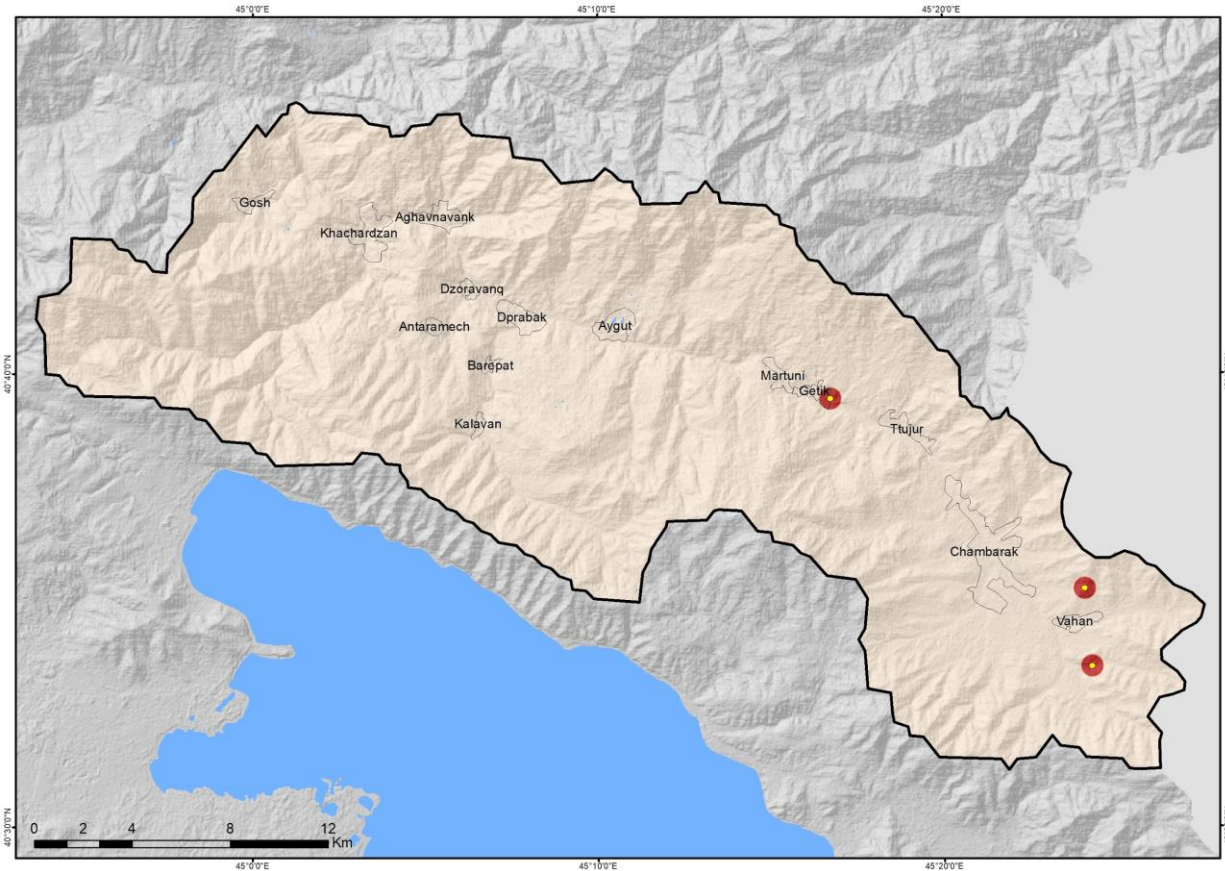
Figure 16: Spatial distribution of analysis result of wild animals/game for food getting areas in the Getik Valley

2.3.12. Where is your arable land located?

The survey participants stated that there are many arable lands and overall they are satisfied with the soil quality. The issues that were most mentioned by the locals related to irrigation and landslides.

There were 85 responses and the map below (Figure 17) shows the results of the spatial analysis. The arable lands are mostly located in the southern part of the area. It is worth to mention, that some of the arable lands turned into grasslands or pastures over the past few years.
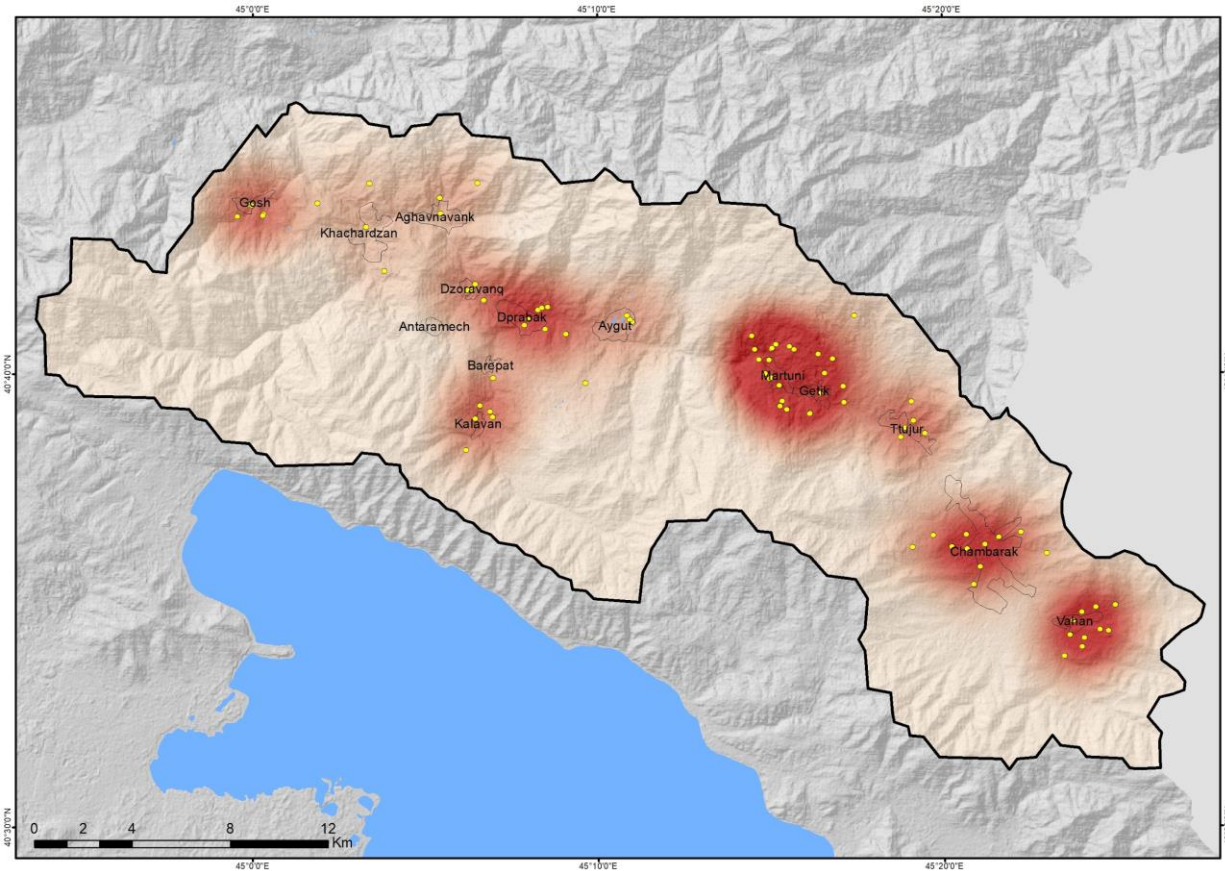
Figure 17: Spatial distribution of analysis result of arable lands in the Getik Valley

2.3.13. Where do you take tourists?

There are numerous sightseeing locations in Getik Valley that would interest tourists. According to the survey participants, the most popular places for tourists are Lake Sevan and Sevanavank (church). Sometimes the locals also show to the tourists the ruins of destroyed monuments. Another place mentioned by locals is Goshavank, where a nice area for tourists has been created around the church. There are sightseeing locations in almost every community in Getik Valley. In Martuni village, one villager shows the tourists the whole process of making honey (as mentioned before).

As shown in Figure 18, there are two obvious clustering areas mentioned by survey participants (57 total answers for this question): Gosh and Kalavan, which are main tourist sites in this region.
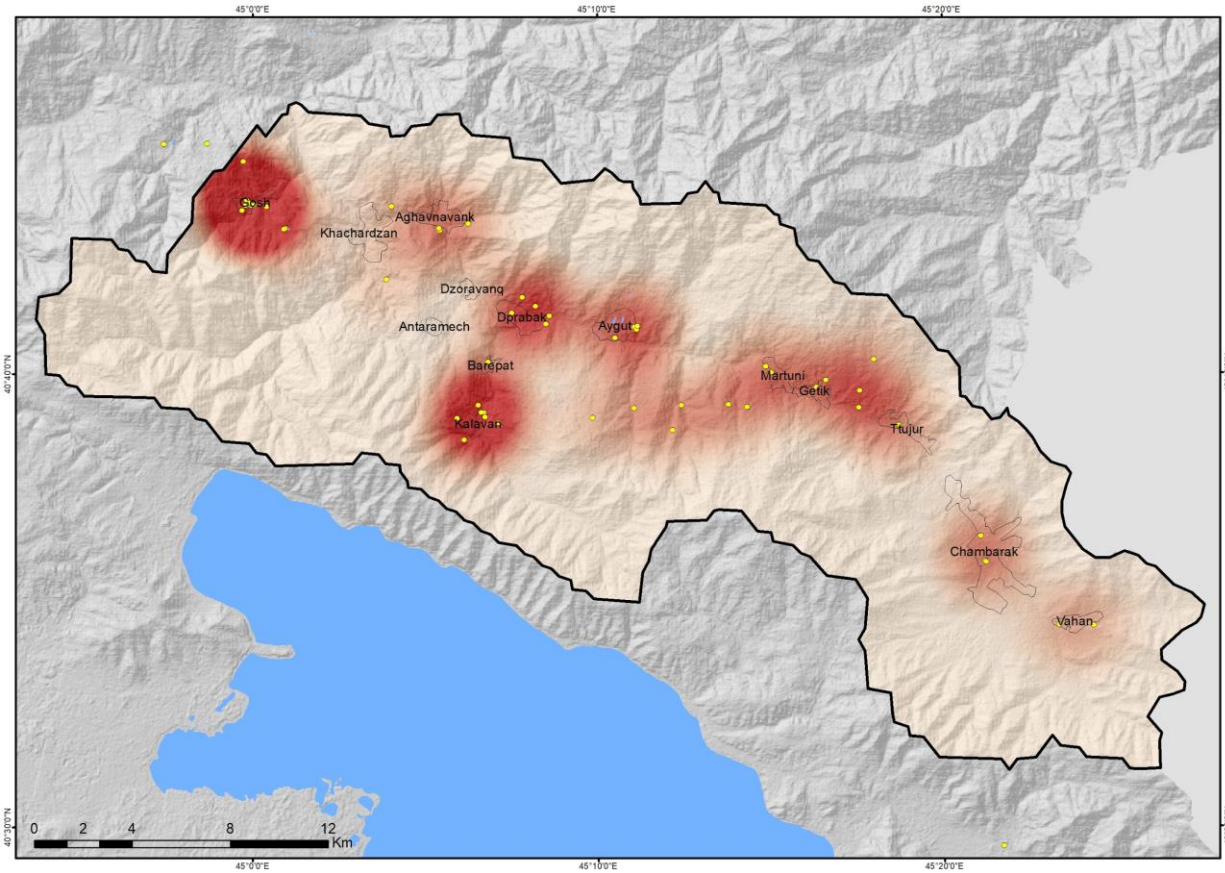
Figure 18: Spatial distribution of analysis result of tourists taking areas in the Getik Valley

2.3.14. Where do you go for recreation (taking a walk, relaxation, hiking, biking)?

According to the responses of the survey (overall 56 answers for this question), people living in Getik Valley get rest while working in the fields, which are located near their communities. Figure 19 shows the hotspot areas located around the communities.

Most of the respondents mentioned that there are no proper roads for cycling. Some of them also mentioned Lake Sevan as a recreation area.
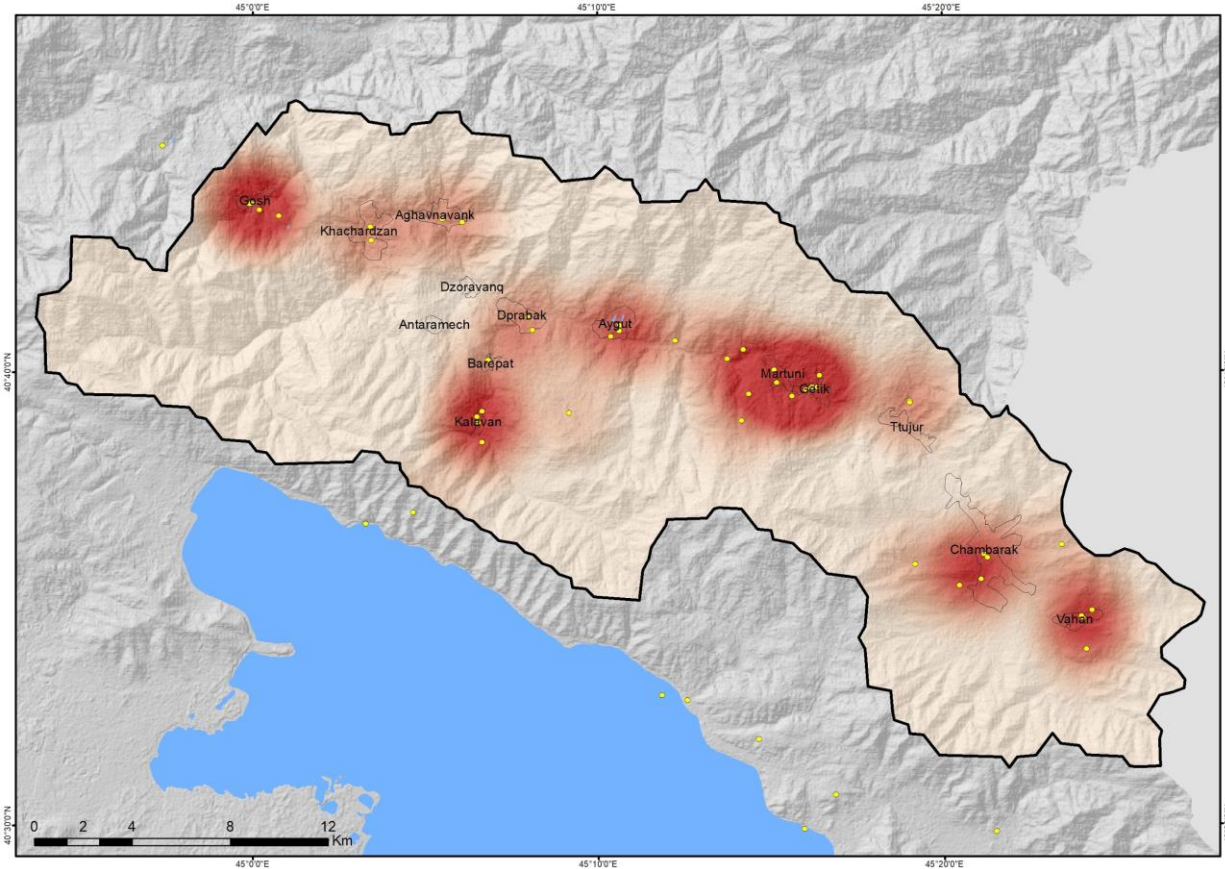
Figure 19: Spatial distribution of analysis result of recreation areas in the Getik Valley

2.3.15. Have you noticed any landscape changes around your village or in the Getik valley in the last 30 years?

The majority of survey participants pointed out places that have been changed as a result of landslides. As a consequence, many residential buildings and constructions have been destroyed. Moreover, many arable lands turned into grasslands because of the absence of water, preventing people from growing vegetables. One issue mentioned by the locals was the sharp decline in the water level of Lake Sevan.

Deforestation was another big change that was mentioned. It is mostly connected to illegal forest cutting, but there are also other reasons, such as erosion and climate change.

Figure 20 shows the land use / land cover map of Getik Valley overlaying with the landscape change areas mentioned by participants. Most of the changes mentioned by people are negative.
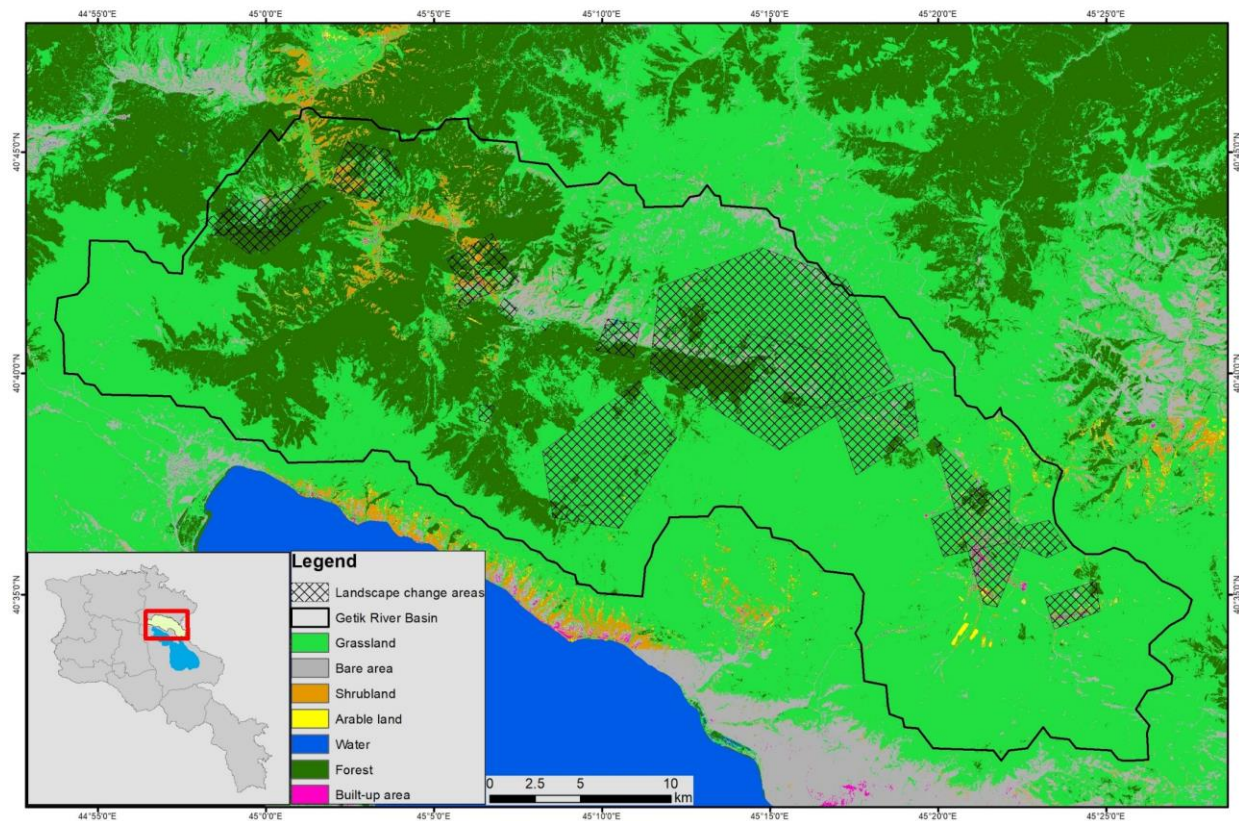

Figure 20: LCLU map and Landscape change areas mentioned by survey participants

3. Results and Discussion

The purpose of this pilot study was to evaluate land use patterns and identify benefits that people receive from the natural environment in Getik Valley. The Internet-based PPGIS was used to colelct data with face-to-face interviews. Another objective of the study was to identify the places of landscape changes to understand the current landscape change tendencies in Getik Valley during the last 30 years. The real time Land Use and Land Cover (LULC) map was compared with the collected data in order to explore and understand human-environment relationship and dynamics that make changes in the environment (Lambin et al., 2003).

There were in total 119 respondents, of which 52% were male and 48% female. Interestingly, the interviews outside were mostly men and interviews at home were mostly women. The interviewers were asking the questions and using tablets to record answers. 53% of participants were between the ages of 31 and 60, 25% were over 60 years old, and 22% were between the ages of 18 and 30.

40.7% of participants had the equivalent of a high school education, 24.6% had finished vocational school, and 22% had a Bachelor's degree. Only 6% had a Master's degree or higher and only 6.8% received education up to the elementary school level.

The largest category of occupation for participants was the production sector (e.g., agriculture, forestry) (29.2% of respondents). 25% were homeworkers. Another large occupation category was the service sector (e.g., tourism, public health and medical services, media and communication) (18.8%). 13% were retired and 8% were students. Only 3% were unemployed and only 2% were occupied in the processing sector (e.g., food industry, electrical industry).

As mentioned, the questionnaire included 16 spatial questions, which allowed participants to draw a polygon or place a point to represent a certain area or spot.

The point data include 336 total points, and the polygon data include 824 total polygons available for spatial analysis. As noted in the Data Analysis section, the polygon features were converted into points calculating the centroids of polygons. The percentage of respondents for each spatial question is shown in Figure 21.
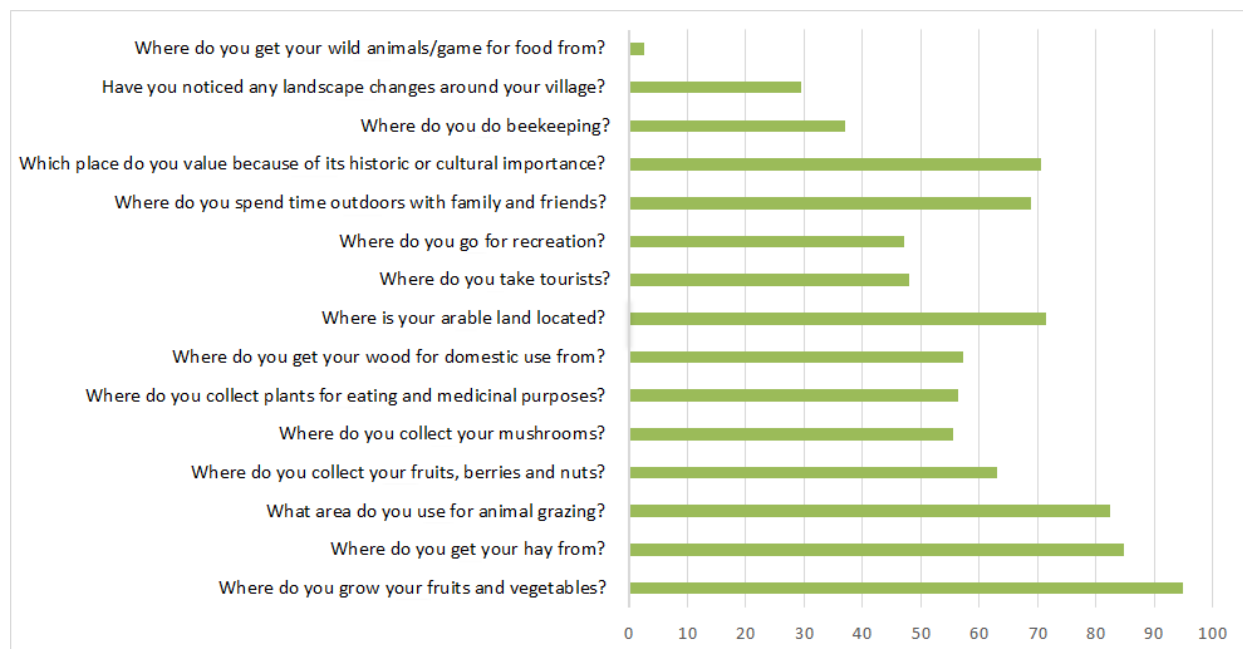

Figure 21: Percentage of respondents for each spatial question

In order to understand the spatial relationship between collected spatial data and main LULC classes, the ArcGIS Spatial Join function was applied. The visualization of the results is shown in Figure 22.
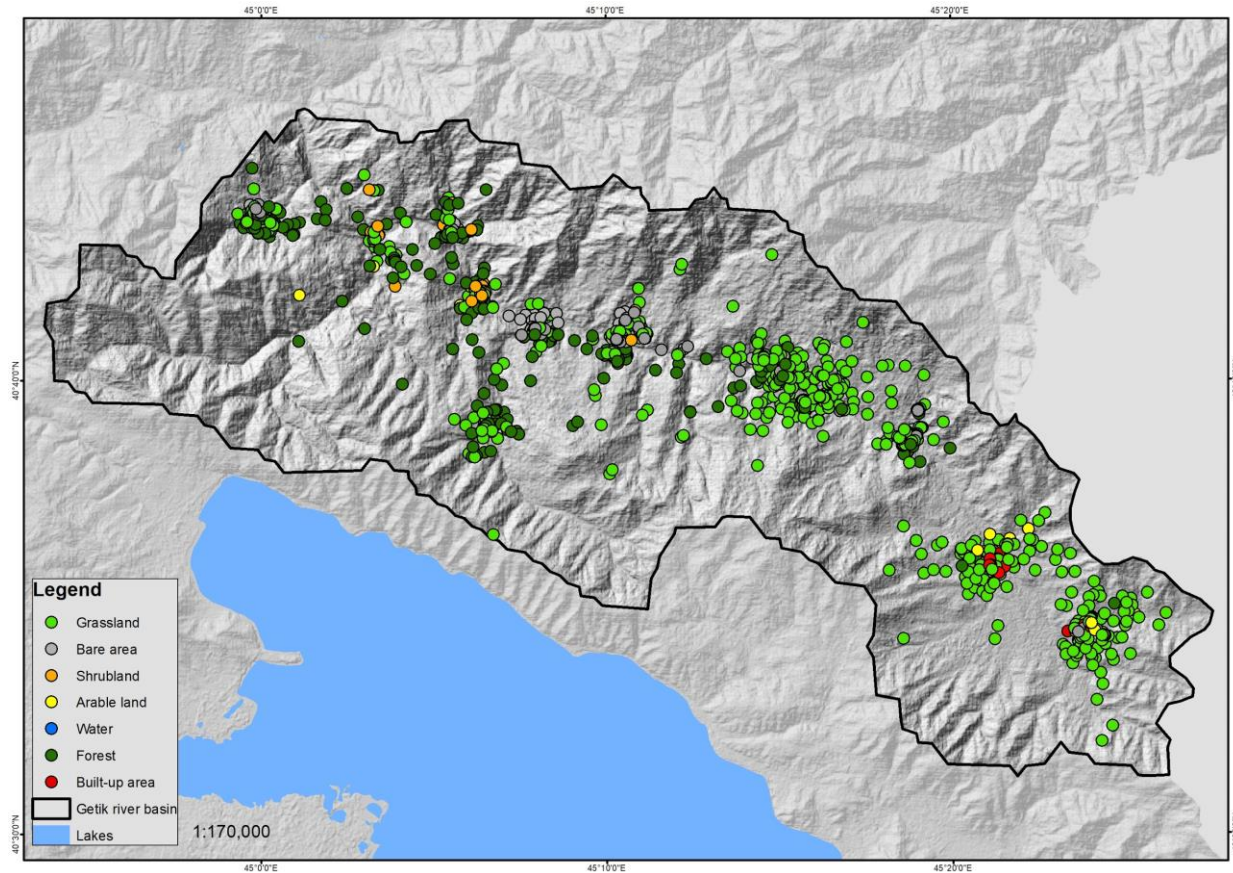
Figure 22: Spatial relationship between collected spatial data and Land Use and Land Cover characteristics of Getik Valley

After applying the Spatial join tool, the information stored in the attribute table of GIS shapefile (visualized in Figure 20) was used to create a table in order to show the relationship between collected datasets and LULC values. Only the values with significant relationships were selected for analysis.

According to the data presented in Table 2, 55% of participants noticed landscape changes in grasslands. The main purpose of this is that many arable lands turned into grasslands because of the absence of an irrigation system. As the LULC map is based on real-time data, the former arable land areas were classified as grasslands. However, the footprint of agricultural activities was visible in these areas. 29% of locals mentioned changes in forested areas, specifically deforestation connected with illegal cutting.

63% of interviewees are using grasslands for animal grazing, but 20% of them are using forested areas, which can have a negative effect on forest growth (Piana and Marsden, 2014).

Table 2: Percentage showing relationship between collected datasets and LULC values.

	Grassland	Bare area	Shrubland	Agriculture	Water	Forest	Built-up area
Where did you see these landscape changes?	55	11	0	5	0	29	0
What area do you use for animal grazing?	63	9	5	1	1	20	1
Where do you go for recreation (taking a walk, relaxation, hiking, biking)?	63	17	0	0	0	15	5
Where do you spend time outdoors with family and friends (e.g. having a picnic or barbecue)?	56	14	4	0	0	25	1

The questions about recreation areas and outdoor time with families and friends were sometimes perceived as the same question. There is significant connection between those questions, and grassland and forest land cover values. Thus, there is a strong connection to nature and the outdoors.

4. Recommendations

This pilot study was conducted to reveal information about land use patterns and landscape changes in the communities of Getik Valley, Armenia. To improve the questionnaire, we recommend a few changes presented below.

The major recommendations are related to the types of questions included in the questionnaire. For instance, the question about historical-cultural places that are appreciated by the respondent's needs be restructured; it needs to have a space to type the exact name of the place as an open-ended question besides pointing on the map.

The question about the grasslands and agricultural lands needs to be reformulated as most of the respondents did not discriminate the difference immediately.

There was also a problem with the map, which was not detailed enough and did not contain enough orienting points to show exact places. We suggest creating a more detailed map with at least the most well-known places in the community, such as the bus stop, the school, the municipality, the river, etc. The size of the land described by the respondents is not accurate on the map, as the respondents themselves were not able to describe the size and the exact location on the map.

Although there was also a problem with the Internet connection on high spots of the Valley, the issue was solved by the research coordinators by providing the interviewers with maps and questionnaires in hard copies.

5. Acknowledgements

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