Working Paper

Energy Use and Demand of Communities in Getik Valley, Armenia

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This project is a part of the DAAD-funded collaboration, GAtES (German-Armenian Network on the Advancement of Public Participation GIS for Ecosystem Services as a Means for Biodiversity Conservation and Sustainable Development), between the University of Hohenheim (UHOH) and the American University of Armenia's (AUA) Acopian Center for the Environment.

1. Introduction

The identification and assessment of ecosystem services have a crucial role in biodiversity conservation, sustainable development, and multi-use landscapes management (Ouko et al., 2018). To better understand the ecosystem services mainly provided by forests and the benefits that communities get from the natural environment, this project was conducted in the Getik Valley of Armenia (Figure 1). The main goals of the project are to identify the intensively used areas, especially forested areas, and provide information to communities in order to help them improve and prolong the use of natural resources.

The Public Participation GIS (Geographic Information Systems) Internet-based system was used to develop a questionnaire[1] for collecting information. The Public Participation GIS (PPGIS) is a suitable method for combining public and expert knowledge for better decision-making and successful land planning (Zolkafli et al., 2017).

The questionnaire consists of two types of questions: 1) non-spatial questions, which are mainly open and multiple-choice questions, and 2) spatial questions, which allow the respondent to draw a polygon or place a point, representing a certain area or spot.

Thus, the questionnaire was used to reveal the following information:

- the land use patterns and landscape changes in the study area,
- the energy sources and energy demand of the local communities.

This report focuses on the analysis of collected non-spatial data related to energy use and energy demand in order to understand the role that firewood plays in fulfilling the energy demand of the local communities. The report also summarizes data regarding the use of fertilizers and pesticides in the Getik Valley.

In Section 2, data analysis is reported including simple data analysis and inter-variable dependency analysis. In Section 3, the overall results are discussed. In Section 4, recommendations are given for improving the questionnaire.

This research project is a part of the DAAD-funded collaboration, GAtES, 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.

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

2. Data Analysis

2.1. Study Area and Target Group

The target group of this research project is the communities of the Getik River Basin (Figure 1) that have lived there for at least six months.

The Getik River Basin is located northeast of Lake Sevan and includes the Chambarak consolidated municipality in Gegharkunik Region and some part of the Dilijan consolidated municipality in Tavush Region. There are 14 communities in the study area, including Gosh, Khachardzan, Aghavnavank, Dzoravank, Antaramej, Dprabak, Barepat, Kalavan, Aygut, Martuni, Getik, Ttujur, Chambarak, and Vahan. Overall, 119 individual interviews were conducted.

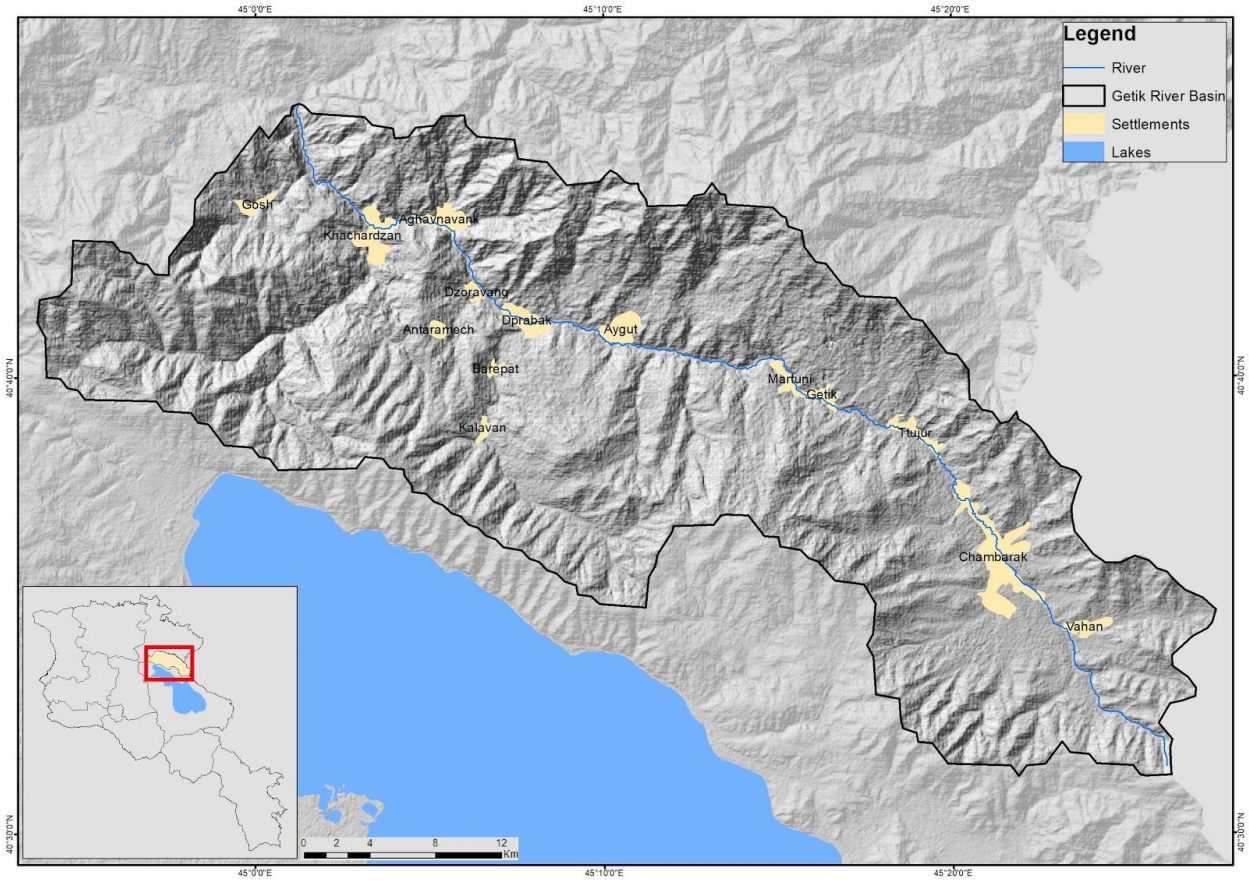

Figure 1: Location of the Getik Valley, Armenia.

Getik Valley, through which Getik River runs, is situated between the mountain ranges of Miapor and Areguni. The entire catchment covers an area of 581 km^2. The elevation in the study ranges from 898 m to 2985 m.

Chambarak is the largest community with a population of 5,652. Overall, there are 14 settlements in the study area and the total population is 12,549 as of January 1st, 2018. Agriculture is the leading branch of the community's economy and the main sphere of employment of the population.

Compared to agriculture, industry is poorly developed. More than 90% of the natural forests of the Gegharkunik Region are situated in the study area. Manufacturing is the main trend of industry and the food industry has a bigger role (www.armstat.am). The Getik River Basin is one of the developing centers of rural tourism in Armenia.

The interviews took place on five different days: September 15th, 16th, 22nd, 30th, and October 7th, 2018. Participants were interviewed either at home or outside.

2.2. Raw Data Description

The raw data include binary values because of the format of the given questions. As the questions were in multiple-choice format, we modified the raw data into a multimodal matrix for each question. This concerns both qualitative and quantitative values.

Overall, there were 28 questions and 35 follow-up questions that referred to a previous answer of a multiple-choice question.

2.3. In-Depth Analysis

In order to obtain an in-depth analysis and relevant interpretation of the data, we studied the correlation matrix. We fixed the significance threshold for correlation coefficients to |0.5|, which means that the significance will be studied for the questions and answers which have correlation coefficients greater than 0.5 and lower than (-0.5). This choice cannot be justified scientifically.

2.3.1. Energy Use

What do you primarily use for cooking?

Simple Data Analysis

The survey performed in the study area of Getik Valley displayed significant preferences for natural gas (67%) and wood (18.5%) as energy sources for cooking.[2] According to the Figure 2, the use of electric energy or manure is considerably less.

[2] The section representing 10% of other energy sources were reflecting double answers (two or more energy sources used), since we did not have the option to choose several answers at the same time; non-significant and redundant answers.

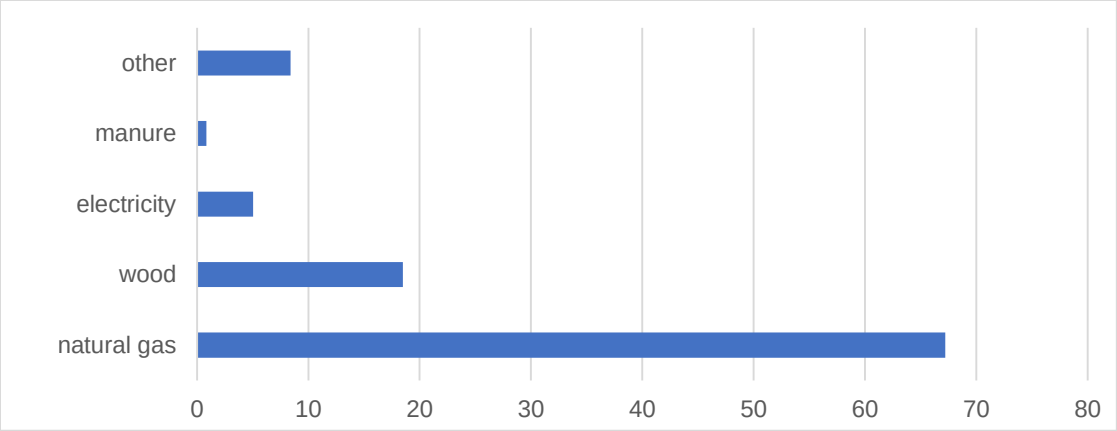

Figure 2: The distribution of the energy sources used for cooking in Getik Valley, Armenia (%).

Inter-Variable Dependency Analysis

According to an in-depth statistical analysis of the inter-variable correlation, we obtained the following results.

Table 1: The correlation coefficients' significance of cooking energy sources[3]

Main source of energy	Have been living there more than 10 years	No changes for landscapes	Use of natural gas for heating water	No changes for energy sources for heating water	Use of wood for heating water	No changes for energy sources for heating home	No changes for energy sources for cooking
Natural gas	50	54	60	60	x	56	57
Wood	x	x	x	x	55	x	x
Electricity	x	x	x	x	x	x	x
Manure	x	x	x	x	x	x	x

[3] All the values are in percentage.

What do you primarily use for heating your home?

Simple Data Analysis

Regarding the energy sources used for heating home, the study showed a meaningful preference for wood (62%), manure (17%), and natural gas (16%). According to the Figure 3, the use of electric energy as a heating source is once again less frequent.

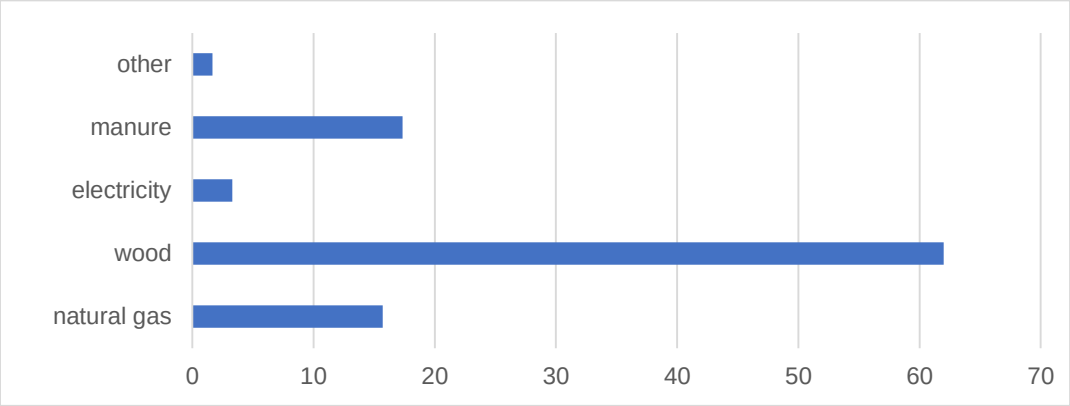

Figure 3: The distribution of energy sources used for heating homes in Getik Valley, Armenia (%).

Inter-Variable Dependency Analysis

There is no significant inter-dependency between this variable.

What do you primarily use for heating water to wash clothes or to take a bath/shower?

Simple Data Analysis

The energy sources used for heating water to wash clothes or to take a bath/shower preferred by interviewed population are natural gas (50%), wood (28%), electricity (16%), and solar energy (4%). According to Figure 4, the use of manure as a heating source for water is least frequent.

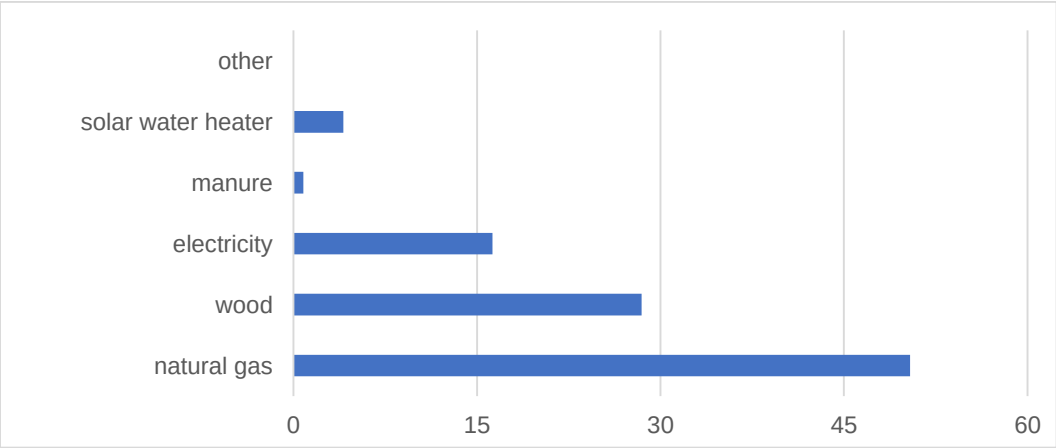

Figure 4: The distribution of energy sources used for heating water in Getik Valley, Armenia.

Inter-Variable Dependency Analysis

An in-depth statistical analysis regarding inter-variable correlation provided the following results.

Table 2: The correlation coefficients' significance of heating water energy sources

Main source of energy	Use of natural gas for cooking	Use of wood for cooking	Substitution of wood to solar energy for heating water	Use of solar panels
Natural gas	67	x	x	x
Wood	x	55	x	x
Electricity	x	x	x	x
Solar energy	x	x	62	72

2.3.2. Energy Demand

In order to understand the energy (heat) demand in the study area, we included the following questions in our questionnaire:

- How many people are living in your household?
- How many rooms does your household use for living?
- How many rooms does your household heat?

According to the survey results, 53.4% of respondents are living with 4-6 people in a household. The overall results are presented in Figure 5.

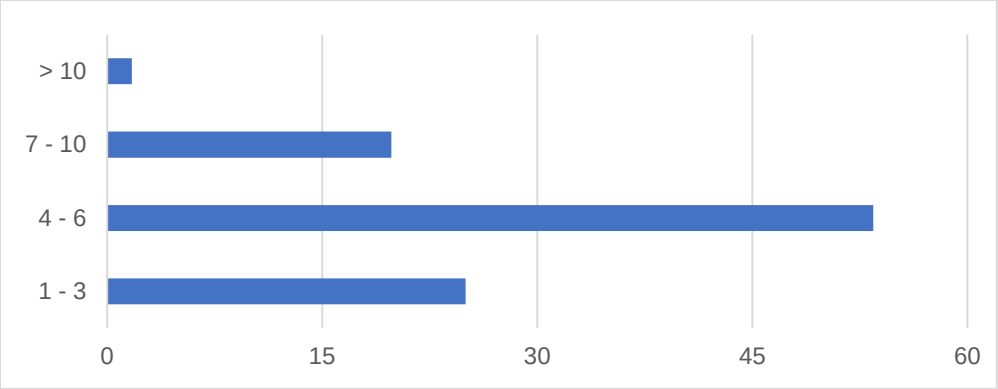

Figure 5: The number of people living in each household in Getik Valley, Armenia (%).

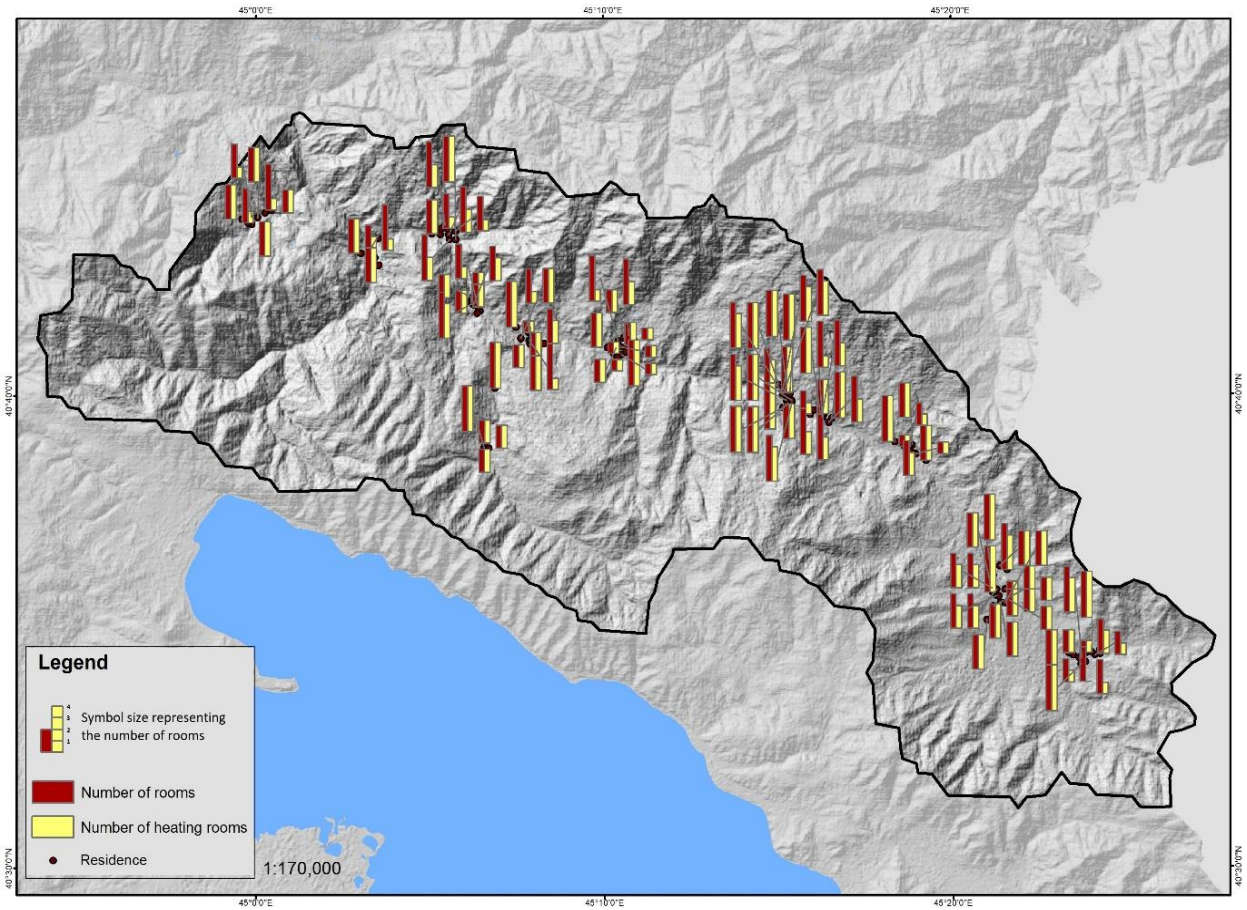

Figure 6: A bar chart map of Getik Valley showing the locations of bar charts that represent the number of rooms and heating rooms in each household.

The results of the survey (Figure 7) show that most households do not heat all of the rooms that they use for living. Figure 6 shows the spatial distribution of the bar charts including the number of rooms that respondents use for living and the number of rooms that they heat.

According to the spatial distribution of the bar charts, the survey participants living in the villages located in the northern parts of the study area heat only one or two rooms during the heating season.

However, they use three or four rooms for living. Nevertheless, a large fraction of the residents living in the southern parts of Getik Valley heat nearly all rooms that they use for living (three or four).

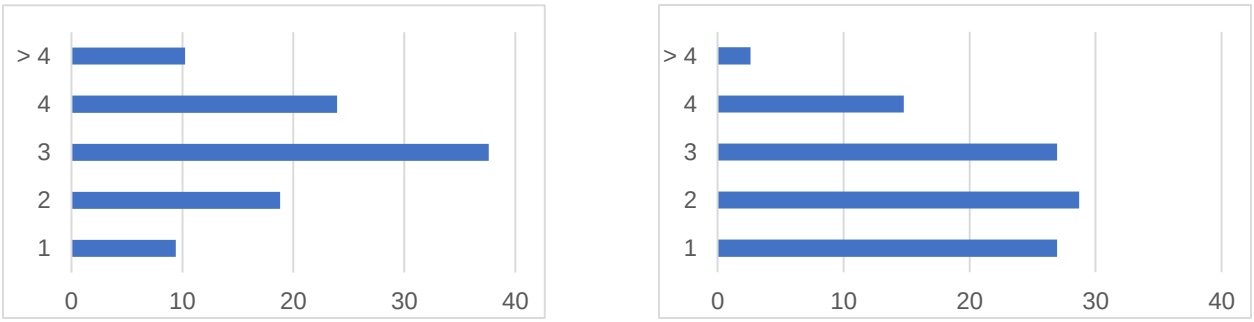

Figure 7: The number of rooms that each household uses for living represented by percentage (left) and the number of heating rooms represented by percentage (right) (%).

2.3.3. Change of Energy Sources

How did you change your primary energy source for cooking in the last five years?

Simple data analysis

There were minimal changes observed in Getik Valley concerning the energy sources used for cooking. 83.5% of the target group did not change their energy source for food preparation in the past five years. The rest of the respondents reported the following[4]:

- Change from wood to natural gas: 8.7%
- Change from manure to wood: 1.7%
- Change from wood to electricity: 0.87%
- Change from natural gas to wood: 0.87%

The suggested variations from one energy source to another for cooking (e.g., from wood to manure, from wood to natural gas, etc.) were not selected by the responders. In this way, they are not included in our statistical analysis.

[4] The section representing 3.5% of other energy sources reflect double answers (two or more changes specified), since we did not have the option to choose several answers simultaneously; non-significant and redundant answers.

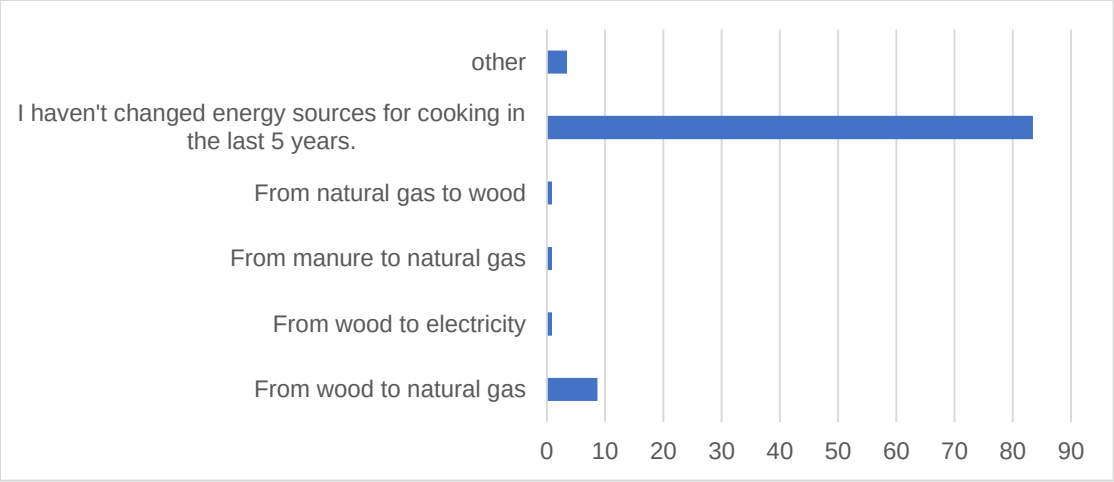

Figure 8: The distribution of changes in the energy sources used for cooking in Getik Valley (%).

Inter-Variable Dependency Analysis

Regarding the correlation matrix analysis for the changes in cooking energy sources, we observed a huge set of statistically significant inter-dependencies between the variables.

Table 3: The correlation coefficients' significance of the variation in energy sources for cooking

Changes from … to …	Change the energy source of heating home from manure to natural gas	Change the energy source for heating water from gas to manure	Change the energy sources for heating home from electricity to manure	Installing new more efficient heaters	Uses mainly natural gas for cooking	Have never changed the energy source for heating home	Have never changed the energy source for heating water
From manure to wood	71	71	x	x	x	x	x
From natural gas to wood	x	x	100	100	x	x	x
No changes	x	x	x	x	57	88	89

How did you change your primary energy source for heating your home in the last 5 years?

Simple Data Analysis

The changes observed in Getik Valley regarding the method of heating homes were non-relevant because of the frequent lack of changes. The fraction of people who have never changed the source for heating homes is 86.8%. The rest of the respondents reported the following[5]:

- Change from wood to natural gas: 4.4 %
- Change from manure to natural gas: 0.87%
- Change from natural gas to manure: 0.87%
- Change from electricity to manure: 0.87%
- Change from wood to electricity: 0.87%
- Change from natural gas to wood: 0.87%

The suggested variations from one energy source to another for home heating (e.g. from manure to electricity, from natural gas to wood, etc.) were not selected by the respondents. Thus, they are not included in our statistical analysis.

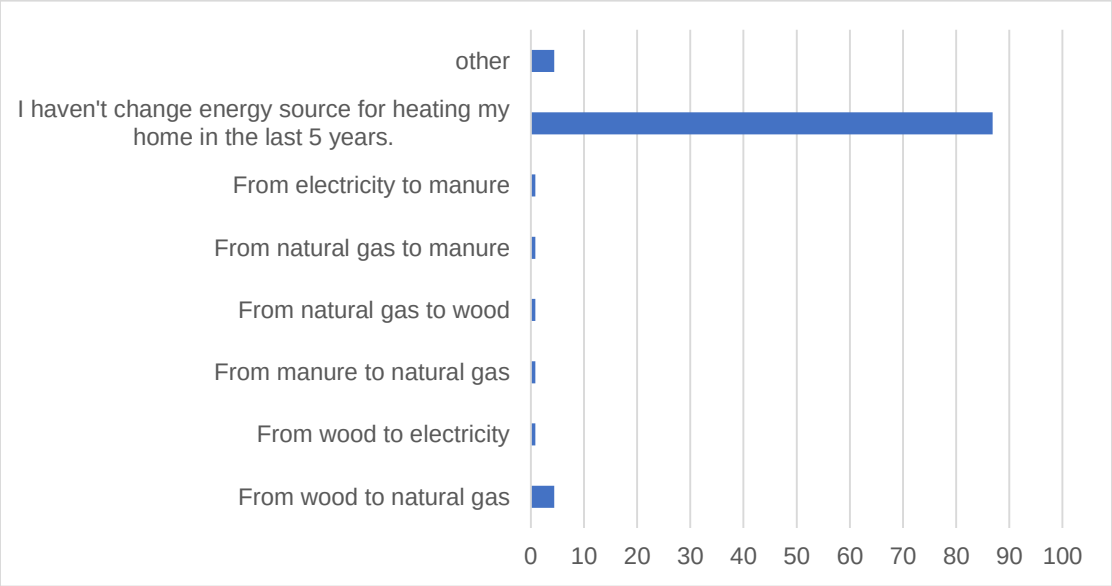

Figure 9: The distribution of changes in energy sources used for heating home in Getik Valley, Armenia (%).

[5] The section representing 3.5% of other energy sources reflect double answers (two or more changes specified), since we did not have the option to choose several answers simultaneously; non-significant and redundant answers.

Inter-Variable dependency analysis

Regarding the correlation matrix analysis for the changes in heating home energy sources, we observed a huge set of statistically significant inter-dependencies between the variables.

Table 4: The correlation coefficients' significance of the variation in energy sources for heating home

Changes from … to …	Change the energy source of heating water from wood to natural gas	Change the energy source for cooking from manure to wood	Change the energy source for cooking from natural gas to wood	Change the energy sources for heating water from natural gas to manure	Installing new more efficient heaters	Uses mainly natural gas for cooking	Have never changed the energy source for cooking	Have never changed the energy source for heating home
From wood to natural gas	66	x	x	x	x	x	x	x
From manure to natural gas	x	70	x	100	x	x	x	x
From electricity to manure	x	x	100	x	100	x	x	x
No changes	x	x	x	x	x	56	88	90

How did you change your primary energy source for heating water to wash clothes or to take a bath/shower in the last 5 years?

Simple data analysis

The changes observed in Getik Valley regarding the way of heating water show us the identical tendency. The rate of people who have never changed the source for heating water is 87.5%. The rest of the responders are showing the following results[6]:

- Changes from wood to natural gas: 3.6 %
- Changes from wood to solar energy: 1.8 %
- Changes from natural gas to manure: 0.9%
- Changes from wood to electricity: 3.6 %

[6] The section representing 3.6% of other energy sources were reflecting double answers (two or more changes specified), since we did not have the option to choose several answers at the same time; non-significant and redundant answers.

The suggested variations from one energy source to another for home heating (e.g. from wood to manure, from manure to natural gas, etc.) were not selected by the responders. In this way, they are not included in our statistical analysis.

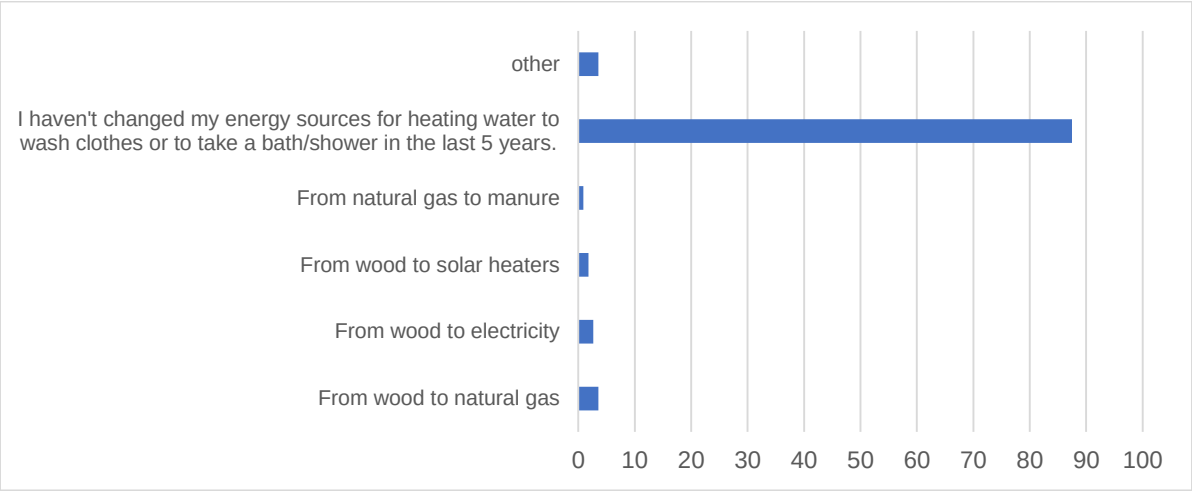

Figure 10: The distribution of changes in the energy sources used for heating water in Getik Valley (%).

Inter-variable dependency analysis

Regarding the correlation matrix analysis for the changes in water heating sources, we observed a huge set of statistically significant inter-dependencies between the variables.

Table 5: The correlation coefficients' significance of the variation in energy sources for heating water

Changes from … to …	Change the energy source of heating home from wood to natural gas	Change the energy source for cooking from manure to wood	Change the energy source for heating home from manure to natural gas	Uses manly solar energy for heating water	Carrying about using solar panels for heating water	Uses mainly natural gas for cooking	Have never changed the energy source for cooking	Have never changed the energy source for heating home
From wood to natural gas	66	x	x	x	x	x	x	x
From wood to solar heater	x	x	x	63	57	x	x	x
From natural gas to manure	x	71	100	x	100	x	x	x
No changes	x	x	x	x	x	60	89	90

2.3.4. Energy Practices

To reveal information about energy practice in Getik Valley, the question was included in the questionnaire and the results are shown in Figure 11. According to the survey participants, 25% have European windows installed and 22% use LED lamps for lighting. 33.6% have chosen the answer “None of those” and nearly 1% have chosen “Other”. Although we included a follow-up question, no specification was given by participants.

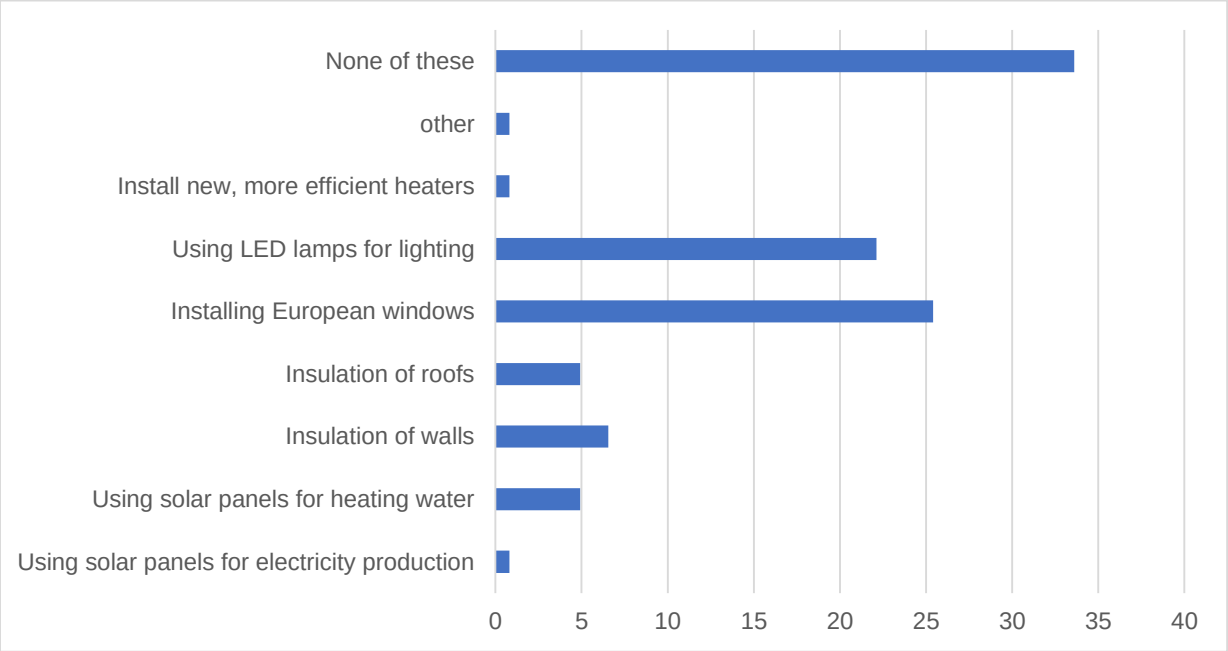

Figure 11: Energy practice in Getik Valley

2.3.5. Fertilizer and Pesticide Consumption in the Context of Energy Use

The survey analysis shows that 14% of the target group uses fertilizers for grasslands and 40% use fertilizers for agricultural fields. It is important to highlight that 67% does not use fertilizers for grasslands (86%) does not also use it for agricultural fields (60%). Concerning the use of pesticides both for agricultural fields and grasslands, only 8% use pesticides for grasslands in comparison of 26% who use pesticides for agricultural fields. 70% does not consume pesticides for grasslands and prefers to not use them for agricultural fields.

All other correlation indicators related to the energy use are not specified in this study because of the absence of significant links between the variables.

3. Results and Discussion

To understand the role that firewood plays to fulfill the energy demand in Getik Valley, this research project was conducted. The exploitation of forest can lead to degradation of resources, which can be a significant problem not only for ecosystems, but also for communities. It is very important to involve local communities in the management process, since their local knowledge is irreplaceable for sustainable management of natural resources and ecosystem services.

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).

85% of respondents lived in the study area for more than 10 years (for details on demographics of the sampled households see Appendix A).

The role of firewood is quite high in the study area for fulfilling the energy demand. Nearly 62% of respondents use wood for heating their homes. 28% use wood for heating water to wash clothes or to take a bath/shower, and 18% use wood for cooking.

In order to obtain an in-depth analysis and relevant interpretation of the data, the correlation matrix was used. According to the correlation matrix, there are large set of statistically significant inter-dependencies between the variables. Table 6 presents the inter-dependencies between the variables that have a correlation coefficient of 100%.

Table 6: The correlation coefficients' with high significant values between the variables

Variables Tested	Change the energy sources for heating home from electricity to manure	Installing new more efficient heaters	Change the energy sources for heating water from natural gas to manure	Change the energy source for cooking from natural gas to wood	Change the energy source for heating home from manure to natural gas	Carrying about using solar panels for heating water
Change of energy source for cooking from natural gas to wood	100	100	x	x	x	x
Change of energy source for heating home from manure to natural gas	x	x	100	x	x	x
Change of energy source for heating home from electricity to manure	x	100	x	100	x	x
Change of energy source for heating water from natural gas to manure	x	x	x	x	100	100

According to Table 6, there are interesting inter-dependencies between the variables. All the respondents who changed their energy source from natural gas to wood for cooking also changed the energy source for heating their home from electricity to manure. Additionally, 100% of them installed new, more efficient heaters.

100% of respondents who have changed the energy source for heating their homes from manure to natural gas also changed the energy source for heating water from natural gas to manure.

All respondents who changed the energy source for heating their homes from electricity to manure also changed the energy source for cooking from natural gas to wood and installed new, more efficient heaters.

The correlation matrix shows that all respondents who changed their energy source for heating water from natural gas to manure also changed the energy source for heating their homes from manure to natural gas. Also, all of them using solar panels for heating water.

4. Recommendations

This pilot study was conducted to reveal information about energy use, demand, and practice in the communities of Getik Valley, Armenia. To improve the questionnaire, we recommend the inclusion of a few more questions presented below.

The results of the analysis show that the role of firewood is significant in the study area, which can lead to forest degradation. In order to understand the reason of the high demand for wood, we recommend including a question about gas supply and its accessibility for each household.

It is also important to incorporate a question about the price of wood for the last five or ten years and compare that information with the use and demand of fuelwood and timber in order to better understand the price impact on the use of wood.

We also recommend to include the question about usage of wood for each household in cubic meters.

The questionnaire includes questions about the number of rooms for each household used for living and the number of heating rooms during a heating season. Examining the bar chart map (Figure 6), we assume that the difference of results between the northern and southern parts of the communities can be connected to the difference between apartments and houses. Thus, we recommend to include also a question about apartments and houses (where the respondent lives: in an apartment or in a house), in order to understand the results of spatial distribution.

The questionnaire was developed using Maptionnaire, which is an Internet-based system. Although there was a problem with the Internet connection in the study area, we distributed the questionnaire in hard copies.

5. Acknowledgements

This research project is a part of DAAD-funded collaboration project, GAtES, between the University of Hohenheim and the American University of Armenia's (AUA) Acopian Center for the Environment. The field work (survey) was conducted by three AUA students: Marta Mamyan, Georges Ohannessian, and Louisa Mkrtchyan, jointly with Yerevan State University student, Karen Vardanyan. The authors further wish to thank Christopher Markosian for his comments and editing the report.

Appendix A

Table A1: Demographics of the respondents

Demographic		Number	Total %
Age of respondent	18-30 31-60 > 60	26 64 30	21.7 53.3 25.0
Highest level of education	Finished elementary school Finished high school Finished vocational school Finished university bachelor Finished university master Higher	8 48 29 26 4 3	6.8 40.7 24.6 22.0 3.4 2.5
Occupation	Occupied in the production sector Occupied in the processing sector Occupied in the service sector Homeworker Student Unemployed Retired Unfit for work or disabled	28 2 18 24 8 3 13 0	29.2 2.1 18.8 25.0 8.3 3.1 13.5 0.0
Living years in the study area	< 5 years 5 – 10 years > 10 years	9 13 122	6.3 9.0 84.7
Living years of respondent's family in the study area	I was the first of my family who moved to this area. My parents are from here. My grandparents are from here. The ancestors of my grandparents are from here.	54 44 33 16	36.7 29.9 22.4 10.9
Living elsewhere	Yes No	88 60	59.5 40.5

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