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Ecological Footprint Reduction Behaviors of Individuals in Turkey in the Context of Ecological Sustainability

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Abstract: While people consume natural resources by interacting with the environment, they also cause some environmental changes. Environmental pollution and construction are among the most important reasons for these changes. In addition, the rate of renewal of natural resources remains slow while consumption is increasing. Thus, biocapacity is slow to renew itself compared to consumption, leading to the emergence of an ecological deficit. The largest share in the ecological deficit belongs to personal consumption. Based on this, the attitudes and behavior of individuals in Turkey to reduce their ecological footprint were examined in the context of ecological sustainability. The survey model was adopted in the study. The data collected from 773 people via the scale and various forms were analyzed. The results of the analysis show that the ecological footprint size in Turkey is above the world average in personal consumption. It has been determined that the participants have significant behavioral deficiencies in the behaviors towards reducing the ecological footprint, such as recycling, reusing the product by repairing, composting, not wasting water, food and clothing, and they tend to use packaged products excessively.

Keywords: biocapacity; ecology; ecological footprint; ecological sustainability; ecological deficit; ecological poverty

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1. Introduction

It is nature, namely the Earth, that provides the resources, such as air, water and soil, that people basically need to survive. While people's needs such as food and energy are increasing in many parts of the world, the ability of our planet to meet these needs is increasingly being eroded by the excessive use of plants, animals and natural resources. In particular, revealing the causes of pressure on natural resources is a prerequisite for sustainable use [1]. However, sustainability is essential for the uninterrupted continuation of life. Economy, society and the environment constitute three important dimensions of sustainability [2,3]. Economic sustainability consists of the proper use of resources, income-expenditure balance, elimination of income distribution inequality, sustainable production, cost and investments, and research and development [3]. Human rights, gender equality, peace and security, cultural diversity and intercultural understanding, social services and social justice are at the heart of social sustainability [4]. Environmental sustainability is only possible by protecting natural resources, achieving a sustainable urbanization, reducing environmental pollution, increasing the use of renewable energy resources, reducing resource use, recycling waste, and minimizing ecological footprint [5–7]. The correct use of resources and reducing the ecological footprint without exceeding the biological capacity form the basis of ecological sustainability.

Ecological sustainability is meeting the needs of the present without compromising the capacity for future generations to meet their needs [8,9]. What makes this sustainability measurable is the ecological footprint. The ecological footprint that emerges as a result of human activities is compared to the amount of natural resources that we can produce

in the same time period, that is, with the biological capacity, and shows whether we live within the limits of natural resources' self-renewal [10]. The ecological footprint is the resource used, while the biocapacity is the resource available. The ecological footprint value is commonly expressed as the required number of worlds or global hectares (gha), to make it more understandable.

Our ecological footprint has been exceeding the Earth's capacity to regenerate since 1970 [11–13]. Estimates of the ecological footprint indicate that human demand exceeds current biocapacity by over 60% [14,15]. It has been determined that the places where human footprints are not seen in the world, in other words, most of the last terrestrial natural areas are within the borders of only a handful of countries (Russia, Canada, Brazil, and Australia) [6,7,16]. However, data from the United Nations Environment Program show that our per capita global stock of natural capital has decreased by about 40% since the early 1990s, capital produced has doubled and human capital has increased by 13% [17].

With the overuse of natural resources and the growing ecological footprint of the world, the signs of ecological deficit, in other words global excess, are becoming more evident [18–21]. Climate change [22], loss of biodiversity [23–25], risk of extinction of species and fisheries collapse [26] reaching the atmospheric carbon limit [27], increased risk of viral transmission due to ecological factors [28], pressure on the ecosystem [29,30], and freshwater scarcity [17] indicate that the planetary limit has been crossed. In the face of these threats, global solutions have been tried to be produced with international agreements such as the Paris Agreement [31], Aichi Biodiversity Targets [32] and The Sustainable Development Goals [33].

Studies on land/land use [24,34], population density [35], forests [36], climate change [37,38], and biodiversity [23,39,40] present limited data in relation to the human footprint and its effect on pressure [41–43]. Ecological footprint has been investigated based on income [44,45], commodity prices [46], globalization [47], politics [48] and socio-economic indicators [49] in addition to human population growth. All these studies emphasize that the ecological footprint is associated with broader economic and social changes.

The components of the ecological footprint are carbon footprint, agricultural land footprint, forest footprint, grassland footprint, built area footprint and fishery field footprint [17]. The largest of these components is personal consumption, which is closely related to all components. While it varies according to the countries and the place of residence, the share of personal consumption in the ecological footprint is not less than 80% [5]. The high rate of personal consumption is due to the fact that all production and services, such as food, industrial products, transportation and housing, are included in this category. Factors such as public space and national security are examined in the category of social footprint.

Average ecological footprint for humanity is 1.7 Earths (gha), and this global ecological overshoot continues to grow [15,50]. In other words, humans use the equivalent of 1.7 planets (Earth) to sustain their activities. This means that 1.7 years are needed to reproduce the natural resources that people consume in a year and to capture the carbon dioxide they release into the atmosphere. Most countries, and the world as a whole, have an ecological deficit, with more than 85% of the world's population living in countries with ecological deficits [51] and the ecological poverty of countries is increasing. According to 2018 data in Turkey, ecological footprint per capita is 3.4 Earth (gha), biocapacity per capita is 1.3 Earth (gha), and biocapacity deficit is 2.1 Earth (gha) [52]. While Turkey's ecological footprint and biological capacity per capita were equal (2.0 gha) in 1983, the biocapacity deficit increased steadily and rapidly after this year [52]. As a matter of fact, the biological capacity is decreasing while the ecological footprint is growing in Turkey.

The largest share of Turkey's total ecological footprint, with 46% (1.24–1.36 kha per capita), comes from the carbon footprint, the demand required to trap CO_2 emissions [17]. The trace resulting from the demand for agricultural lands constitutes approximately 35% of the ecological footprint here. The bulk of the agricultural footprint (83%) is food related. The share of demand for forest products in Turkey's ecological footprint is 11%, the share

of grazing lands is 3%, the share of built-up land use is 3%, and the share of fisheries and aquaculture is 2% [17]. The top three largest ecological footprint components in Turkey are personal consumption (82%), investment expenditures (social infrastructure, factories, housing, etc.) with 13% and social footprint (public space and defense services) with 5%. The share of food in personal consumption is 52%, the share of products is 21%, the share of transportation is 15%, the share of services is 6%, and the share of residences (resources used for living spaces) is 6% [5].

It is not difficult to predict that the ecological footprint will constantly grow and ecological poverty will increase, considering the fact that human population will reach an estimated 9.8 billion by 2050 [53], a fifth (22%) of plant species in the world is in danger of extinction [26], the natural capital stock is decreasing by 40% [17], despite the continuous increase in the demand for resources, the pandemic conditions since 2019 until today (2022), conflicts experienced in the world and economic problems. It should not be forgotten that human well-being depends on the health of nature. The economy is not independent of nature. This fact should be acknowledged, biodiversity should be protected, and ecological footprint should be reduced so as not to exceed the biological capacity. Considering that the personal footprint is the largest component of the ecological footprint, it is the focus of this research to see from which consumption categories and behaviors the personal footprint originates, and to understand the relationship between our daily activities and the use of natural resources. As a matter of fact, the individual ecological footprint, which varies from country to country, provides information about the resource performance, risks and opportunities of countries [6,7]. In this context, the behaviors and situations of individuals to reduce their ecological footprint in Turkey were examined in this study in the context of ecological sustainability.

The aim of the study is to investigate the awareness levels of the participants for reducing the ecological footprint in terms of some variables, taking into account the carbon footprint and ecological footprint. For this purpose, answers to the following questions were sought in this study.

1. What is the level of carbon footprint and ecological footprint of the participants?
2. Is there a significant relationship between the gender, age, education level and place of residence of the participants and the carbon footprint and ecological footprint values?
3. Is there a significant relationship between the carbon footprint and ecological footprint level of the participants and their individual behaviors affecting them?
4. Is there a significant relationship between the gender, age, education level and place of residence of the participants and the individual behaviors that determine the carbon and ecological footprint level?
5. Is there a significant difference according to the variables (gender, age, education level, place of residence) in the awareness of the participants about reducing the ecological footprint?
6. Is there a relationship between the participants' awareness of reducing their ecological footprint and their gender, age, education level, and place of residence?

2. Methods

In the research, we aimed to define the current phenomenon by determining the carbon footprint, ecological footprint, and reduction of the ecological footprint of individuals from different age groups. For this reason, we preferred to use the survey method that has a descriptive structure in this research. The survey research method is used to describe the structure of objects, societies, institutions and the functioning of events [54]. The type of survey in which the data collection process is carried out at once is called the cross-sectional survey [55]. In this study, we aimed to determine the awareness of the participants about reducing the ecological footprint, in other words, the characteristics of a cross-section over time were defined by a cross-sectional survey.

2.1. Study Group

The maximum variation sampling method was preferred over the purposive sampling method in the determination of the study group. According to Büyüköztürk et al. [56], determining the different situations that are similar to each other in relation to the problem examined in the universe and conducting the study on these situations defines the maximum diversity sampling [55]. The study group of the research was formed based on the following criteria: Being older than 10 years old, living in different regions/places in Turkey and to be willing to participate in the research. Thus, it was studied with a group having gender, age, place of residence and education level diversity and is shown in Table 1.

Table 1. Participant features.

Participant Features		Frequency (f)	Percent (%)
Gender	Female	502	64.9
	Male	271	35.1
Age	10–13	40	5.2
	14–17	66	8.5
	18–24	85	11
	25–30	64	8.3
	31–35	106	13.7
	36–40	100	12.9
	41–45	120	15.5
	46–50	98	12.7
	51–55	60	7.8
	56–60	24	3.1
	61 years old and over	10	1.3
Education level diversity	Primary school	8	1.0
	Secondary school	55	7.1
	High school	110	14.2
	Undergraduate degree	545	70.5
	Graduate degree	55	7.1
Place of residence	Vilage	49	6.3
	Town	14	1.8
	District center	163	21.1
	City center	547	70.8
	Total	773	100

As can be seen in Table 1, of the 773 participants in the study group, 502 (64.9%) were female and 271 (35.1%) were male. Of these, 40 (5.2%) were 10–13 years old, 66 (8.5%) were 14–17 years old, 85 (11%) were 18–24 years old, 64 (8.3%) were 25–30 years old, 106 (13.7%) 31–35 years old, 100 (12.9%) 36–40 years old, 120 (15.5%) 41–45 years old, 98 (12.7%) 46–50 years old, 60 (7.8%) were 51–55 years old, 24 (3.1%) were 56–60 years old, 10 (1.3%) were 61 years old and over. Eight (1%) of the participants were from primary school, 55 (7.1%) secondary school, 110 (14.2%) high school, 545 (70.5%) have undergraduate degrees, and 55 (7.1%) have graduate degrees. Forty-nine (6.3%) of the participants live in the village, 14 (1.8%) in the town, 163 (21.1%) in the district center and 547 (70.8%) live in the city center. 281 (36.4%) of the participants stated that they knew what ecological footprint was, 249 (32.2%) stated that they had heard of ecological footprint as a concept but did not know what it was while 243 (31.4) had never heard of ecological footprint even as a concept. In this respect, the diversity in the ecological footprint awareness of the participants constituted a source of richness for the comparative analyzes of the research.

2.2. Data Collection Tools and Implementation

Personal information form, carbon footprint and ecological footprint calculation questionnaire items and Awareness Scale for Reducing Ecological Footprint were used to collect

data for the purposes of the present research. Since all data collection tools were to be applied to different age groups; expert opinion (primary school, social studies and geography teacher, adult educator, language and assessment-evaluation specialist) was taken in addition to validity and reliability studies, and finally a study was conducted for their suitability. Data collection tools were piloted to 20 people from different age groups and their comprehensibility was tested. Personal information form was prepared by the researcher. The form included questions about the participants' gender, age, place of residence, education level, and their knowledge of the concept of ecological footprint.

Carbon Footprint and Ecological Footprint Calculation was made with the calculation tools and items used within the scope of the Climate Crisis Project [57] adapted according to the living conditions in Turkey (Appendix A), based on the items in the Global Footprint Network [52]. At the same time, ecological footprint indicators were taken into account in the research [58]. In this context, a total of 41 items were used, including the use of electric vehicles, use of clothing, garbage produced, recycling, reuse, water use (showering, using a reservoir, brushing teeth, using water-saving reservoirs at home, using water-saving products), use of foodstuffs (one day's consumption of animal food, consumption of foods produced in the immediate vicinity, use of organic products, use of vegetables, etc.) composting fruit-vegetable wastes, consuming ready-made meals, using discarded foods, using packaged products), transportation (transportation means, size, number and usage status), home use (house and its features), and energy use (electricity, fossil fuel, etc.). These items also reveal individual behaviors and situations that affect the carbon footprint and ecological footprint (for example: I leave the water on while brushing my teeth. I have an average of a large trash can full per day. I recycle all paper, tin, glass and plastics.). Calculations on the subject were made separately for each participant by the researcher using open access calculation tools [57].

Awareness Scale for Reducing Ecological Footprint was developed by Tekindal, Zabsun, Özel, Demirsöz, and Tekindal [59]. The scale consists of six dimensions, including energy, recycling, transportation, water consumption, food, within the scope of laws, and a total of 30 items. Scale categories are obtained by adding the subscales by scoring as "strongly disagree = 1", "disagree = 2", "undecided = 3", "agree = 4" and "strongly agree = 5". In the comparison of the data obtained from the confirmatory factor analysis of the scale with the fit indexes, it was found that the model had significant, good and acceptable values (χ^2/sd = 2600; RMSEA = 0.079; CFI = 0.921; TLI = 0.910; IFI = 0.921; GFI = 0.803) and the reliability value was found to be Cronbach's Alpha = 0.960 [59]. The Cronbach's Alpha coefficient regarding the reliability of the scale was recalculated within the scope of the research. The total reliability of the scale was found to be 0.923. In addition to the satisfactory validity and reliability values of this scale, it was preferred to be used because its items consisted of statements aimed at raising awareness about reducing the ecological footprint of individuals.

The data collection process of the research was carried out in two stages. In the first stage, the participants were asked about the items for calculating the carbon footprint and ecological footprint through the personal information form. In this first stage, the participants were also asked a question about whether they knew about the concept of ecological footprint to determine their preliminary knowledge and status. At the second stage, the Awareness Scale for Reducing Ecological Footprint was applied to the same participants. At this stage, the participants were asked if they have an idea about ways to reduce their ecological footprints and make efforts to reduce their ecological footprints. Thus, in the data collection process of the research, we tried to create an awareness and consciousness about the concept of ecological footprint, ways to reduce ecological footprint, and the need to make an effort in this regard. "There is only one world for all of us, we can reduce our ecological footprint!" message was conveyed to the participants. All permissions were obtained within the scope of the research (scale usage permission, Ethics Committee permission, voluntary participation consent), information about the research

was given to all participants and the entire data collection process was carried out online by the researcher.

2.3. Data Analysis

The SPSS 21.0 program was used in the analysis of the data obtained with the data collection tool. Kolmogorov-Smirnov test was used to determine whether the research data showed normal distribution, and it was determined that the normal distribution was not achieved (Kolmogorov-Smirnov Sig. 0.000; $p < 0.05$). Since the scale does not show a normal distribution, the Mann Whitney-U test, which is one of the non-parametric tests, was used for independent variables with two categories, Kruskal Wallis H-Test and Spearman Rank Differences correlation test were used for those with three or more categories in the analysis. Mann Whitney-U test and Kruskal Wallis H-Test were used to reveal the significant difference between groups that did not show normal distribution, and Spearman Rank Differences was used to reveal the relationship. When there was a significant difference after the comparisons, the source of the difference was determined by using the Mann Whitney U-Test and Bonferroni correction. In addition, frequencies, percentages and averages were calculated, and the chi-square test was used to examine the relationship between two qualitative variable categories. The normal distribution is not a prerequisite for the chi-square test as the variables must be qualitative.

In addition to statistical significance, effect size was also calculated in comparisons. Eta square (η^2) and r values were calculated to determine the effect size. In the Kruskal Wallis H-Test, eta squared (η^2) values were calculated to determine the effect of independent variables on each dependent variable. When interpreting eta square values, $\eta^2 = 0.1$ is reported as small, $\eta^2 = 0.6$ as medium, and $\eta^2 = 0.14$ as high effect size [60]. Correlation coefficients (r) effect sizes were determined for the Mann Whitney-U test. In its interpretation, the relation between 0.01 and 0.09 was reported as negligible; between 0.10 to 0.29 as low; between 0.30 to 0.49 as moderate; between 0.50 to 0.69 as strong; 0.70 and later is reported as a very strong relationship [60].

The carbon footprint and ecological footprint of the participants were calculated. Annual carbon footprint per capita in Turkey is approximately 7 t of carbon dioxide equivalent greenhouse gas emissions (t CO_2-e) [61]. This level was accepted as the middle value and a new level was defined in order to classify and interpret the research findings more easily. In this context, in the interpretation of the data obtained, 1–3 t (t CO_2-e) was accepted as "low", 3.1–7 t (t CO_2-e) as "medium", more than 7.1 t (t CO_2-e) as "high" level for carbon footprint.

The "required number of worlds (gha)" value is taken into account in the calculation of the ecological footprint. The world ecological footprint average is 2.7 gha per capita and the biological productive area per capita is 1.8 gha [9]. These values were taken into account and a level was defined so that the research findings could be classified and interpreted more easily. Accordingly, in the interpretation of the data obtained, the ecological footprint value of "1 required world number (gha)" was accepted as "low", "1.1–1.8 required world number (gha)" ecological footprint value as "moderate", "more than 1.9 necessary worlds number (gha)" ecological footprint value as "high" level.

3. Results

3.1. Findings on Carbon Footprint, Ecological Footprint and Individual Behaviors

In the research, the carbon footprint and ecological footprint values of the participants were calculated. The results regarding the carbon footprint and ecological footprint levels of the participants are shown in Table 2.

As can be seen in Table 2, it has been determined that the carbon footprint of the participants is "moderate (3.1–7 t CO_2-e)" and the ecological footprint is similarly "moderate (1.1–1.8 gha/required world number)". However, the proportion of participants with a high carbon footprint (13.8%) is substantial. Considering that the carbon footprint is an important component in the ecological footprint, it is expected that both footprint results

will be consistent. However, considering that only individual behaviors/activities, that is direct/primary footprints, are taken into account in the calculation of these footprints, it should not be ignored that the total footprint values of the participants will be much higher together with the indirect/secondary footprints. The carbon footprint average (6500) calculated by considering only the individual behaviors/activities of the participants is at the average damage level, while the ecological footprint average is almost equal to the existing biological productive area.

Table 2. Carbon footprint and ecological footprint levels of the participants.

Footprint	Level						Calculated Average Footprint per Person
	Low		Middle		High		
	f	%	f	%	f	%	
Carbon footprint	158	20.4	508	65.7	107	13.8	6500 t CO_2-e
Ecological Footprint	265	34.3	470	60.8	38	4.9	1.70 gha

According to the results of the two-way chi-square test conducted to determine whether there is a significant relationship between the gender, age, education level, place of residence and carbon footprint and ecological footprint values of the participants, there is no significant relationship between gender and carbon footprint level ($X^2_{(2)}$ = 0.336; p = 0.845, $p > 0.05$) and ecological footprint level ($X^2_{(2)}$ = 1.290; p = 0.525, $p > 0.05$). Between the place of residence (village, town, district center, city center) and carbon footprint level ($X^2_{(6)}$ = 7.147; p = 0.307, $p > 0.05$) and ecological footprint level ($X^2_{(6)}$ = 4.438; p = 0.618, $p > 0.05$) there is no significant relationship. There is no significant relationship between age and ecological footprint level ($X^2_{(20)}$ = 15.230; p = 0.763, $p > 0.05$) and education and ecological footprint level ($X^2_{(8)}$ = 3.915; p = 0.865, $p > 0.05$). However, there is a significant relationship between age and carbon footprint level ($X^2_{(20)}$ = 35,540; p = 0.017, $p < 0.05$) and education and carbon footprint level ($X^2_{(8)}$ = 16.302; p = 0.038, $p < 0.05$). Considering these results, it can be seen that there is a significant relationship between carbon footprint and age and education level. The growth of carbon footprint as individuals get older is explainable and expected. As a matter of fact, the use of vehicles (such as transportation vehicles), products (such as processed food) and natural resources (such as water) that increase the amount of carbon emissions increase as age progresses and therefore the amount of carbon emissions increases. The significant relationship between education level and carbon emissions can be explained especially in relation to income status. In the study, although the participants did not specify their income level exactly, it can be said that there is an increase in the use of vehicles and products that increase carbon emissions because they have a job and spend at the rate of their wages. The values that emerge in the ecological footprint calculation are more meaningful when evaluated together with the biological productive areas of the societies. In this context, it can be stated that there is no significant difference in the individual behaviors that affect the ecological footprint of individuals according to the variables of gender, age, education level, and place of residence.

In the present research, we also tried to determine the most important individual behaviors that affect the carbon footprint and ecological footprint level. According to the results of the two-way chi square test conducted to determine whether there is a significant relationship between carbon footprint and ecological footprint values:

There is a significant relationship between water usage and carbon footprint level in the shower ($X^2_{(8)}$ = 40.296; p = 0.000, $p < 0.05$), reservoir usage status and carbon footprint level ($X^2_{(2)}$ = 21.577; p = 0.000, $p < 0.05$), water use and carbon footprint level in tooth brushing ($X^2_{(2)}$ = 19.190; p = 0.000, $p < 0.05$), using water-saving products and carbon footprint level ($X^2_{(2)}$ = 23.745; p = 0.000, $p < 0.05$), amount of meat consumed and carbon footprint level

($X^2_{(6)}$ = 152.531; p = 0.000, $p < 0.05$), the use of locally produced/organic/natural food products and the carbon footprint level ($X^2_{(2)}$ = 25.566; p = 0.000, $p < 0.05$), convenience food consumption and carbon footprint level ($X^2_{(2)}$ = 12.063; p = 0.002, $p < 0.05$), use of packaged products and carbon footprint level ($X^2_{(2)}$ = 15.061; p = 0.001, $p < 0.05$), vehicles used and carbon footprint level ($X^2_{(6)}$ = 265.618; p = 0.000, $p < 0.05$), means of transportation and carbon footprint level ($X^2_{(6)}$ = 108.625; p = 0.000, $p < 0.05$), house used for housing and carbon footprint level ($X^2_{(6)}$ = 27.462; p = 0.000, $p < 0.05$), using energy and energy efficient products and carbon footprint level ($X^2_{(2)}$ = 26.356; p = 0.000, $p < 0.05$), clothing use and carbon footprint level ($X^2_{(6)}$ = 40,701; p = 0.000, $p < 0.05$), the amount of garbage produced and the carbon footprint level ($X^2_{(6)}$ = 246.005; p = 0.000, $p < 0.05$).

There is a significant relationship between water usage and ecological footprint level in the shower ($X^2_{(536)}$ = 972.166; p = 0.000, $p < 0.05$), water use and ecological footprint level in tooth brushing ($X^2_{(134)}$ = 326.474; p = 0.000, $p < 0.05$), using water-saving products and ecological footprint level ($X^2_{(134)}$ = 165.391; p = 0.003, $p < 0.05$), amount of meat consumed and ecological footprint level ($X^2_{(402)}$ = 1195.923; p = 0.000, $p < 0.05$), use of locally produced/organic/natural food products and the ecological footprint level ($X^2_{(134)}$ = 175,544; p = 0.009, $p < 0.05$), ready-made food consumption and ecological footprint level ($X^2_{(134)}$ = 249.435; p = 0.000, $p < 0.05$), tools used and ecological footprint level ($X^2_{(402)}$ = 1042.265; p = 0.000, $p < 0.05$), means of transportation and ecological footprint level ($X^2_{(402)}$ = 738.246; p = 0.000, $p < 0.05$), house and ecological footprint level used for housing ($X^2_{(402)}$ = 573.988; p = 0.000, $p < 0.05$), using energy and energy saving products and ecological footprint level ($X^2_{(134)}$ = 210.638; p = 0.000, $p < 0.05$), clothing use and ecological footprint level ($X^2_{(402)}$ = 727.043; p = 0.000, $p < 0.05$), the amount of garbage produced and the ecological footprint level ($X^2_{(402)}$ = 823.158; p = 0.000, $p < 0.05$).

From the individual behaviors discussed in the research, the following items emerged as the situations that increase the carbon and ecological footprint the most: Taking a shower where the water is left on for a long time, leaving the water on while brushing, using the toilet at full capacity or leaving the water on, not using water-saving products, consuming more meat and products daily, consuming more food and processed products brought from afar rather than from the immediate environment consuming ready meals, using more packaged products, using more vehicles with high carbon emissions (refrigerator, washing machine, etc.), using fossil fueled transportation vehicles, using houses larger than needed, using more energy, not using energy-saving products, having more clothes than necessary, the behaviors of producing too much garbage and not contributing to recycling.

Based on the variables of the research (gender, age, education level, and place of residence), according to the results of the two-way chi-square test conducted to determine whether there is a significant relationship between the individual behaviors that determine the carbon and ecological footprint level, there is a significant relationship between gender and transportation vehicles ($X^2_{(3)}$ = 15.817; p = 0.001, $p < 0.05$), and gender and the amount of garbage produced ($X^2_{(3)}$ = 37.136; p = 0.000, $p < 0.05$). There is a significant relationship between the use of organic/natural food products produced in the place of residence and in the immediate vicinity ($X^2_{(3)}$ = 23.350; p = 0.000, $p < 0.05$), place of residence and means of transportation ($X^2_{(9)}$ = 22.951; p = 0.006, $p < 0.05$), the place of residence and the house used for shelter ($X^2_{(9)}$ = 268.467; p = 0.000, $p < 0.05$). There is a significant relationship between using wet and water-saving products ($X^2_{(10)}$ = 38.676; p = 0.000, $p < 0.05$), age and amount of meat consumed ($X^2_{(30)}$ = 60.214; p = 0.001, $p < 0.05$), age and consumption of ready meals ($X^2_{(10)}$ = 44.207; p = 0.000, $p < 0.05$), age and using packaged products

($X^2_{(10)}$ = 29.794; p = 0.001, $p < 0.05$), age and vehicles used ($X^2_{(30)}$ = 157.628; p = 0.000, $p < 0.05$), age and means of transportation ($X^2_{(30)}$ = 59.803; p = 0.001, $p < 0.05$), age and the amount of garbage produced ($X^2_{(30)}$ = 66,865; p = 0.000, $p < 0.05$). There is a significant relationship between education level and use of water in the shower ($X^2_{(16)}$ = 31.335; p = 0.012, $p < 0.05$), the level of education and the use of locally produced/organic/natural food products ($X^2_{(4)}$ = 24.164; p = 0.000, $p < 0.05$), education level and fast food consumption ($X^2_{(4)}$ = 15.899; p = 0.003, $p < 0.05$), education level and means of transportation ($X^2_{(12)}$ = 71.433; p = 0.000, $p < 0.05$), education level and the house used for housing ($X^2_{(12)}$ = 44.856; p = 0.000, $p < 0.05$), education level and clothing use ($X^2_{(12)}$ = 27.255; p = 0.007, $p < 0.05$).

3.2. Findings on Reducing Ecological Footprint with Individual Behaviors

In this study, we tried to determine the state of awareness of the participants towards reducing the ecological footprint and what behaviors they performed in order to reduce the ecological footprint individually in their lives. In this context, the awareness of the participants towards reducing the ecological footprint is shown in Table 3.

Table 3. Awareness of the participants towards reducing the ecological footprint.

Size/Scale	N	$\overline{X}$	ss
Energy	773	4.51	0.508
Under the Law	773	4.66	0.487
Recycle	773	3.95	0.791
Transport	773	3.78	0.799
Water Consumption	773	4.18	0.655
Food	773	4.02	0.654
Scale Total	773	4.20	0.494

When the findings related to the Awareness Scale for Reducing Ecological Footprint and its sub-dimensions are examined in Table 3, it is seen that the highest average is in the sub-dimension within the scope of the law. This is followed by energy, water consumption, food, recycling, and transportation. It can be stated that the general average of the scale is "high". It can be concluded that the enforcement power of laws, energy, water and food consumption, recycling and transportation have an important place in awareness and behaviors towards reducing the individual ecological footprint.

The findings regarding the comparison of the participants' awareness of reducing the ecological footprint by gender are shown in Table 4.

Table 4. Mann-Whitney U Test results by gender.

Group	N	Xrow	∑Row	U	Z	*p*	r
1 woman	502	386.88	194,216	67,963	−0.020	0.984	-
2 men	271	387.21	104,935				

According to Table 4, there is no significant difference between the mean rank of female participants (386.88) and the mean rank of male participants (387.21) in the awareness of reducing the ecological footprint (U = 67,963; Z = −0.020; $p > 0.05$). This finding is similar to the behavior of individuals based on the ecological footprint calculation. Gender does not make a significant difference in the awareness of reducing the ecological footprint, in addition to the value in the calculation of the ecological footprint.

The findings regarding the comparison of the participants' awareness of reducing the ecological footprint by age are shown in Table 5.

Table 5. Kruskal Wallis H Test results by age.

Age	N	Xrow	df	x^2	*p*
1. 10–13 years old	40	348.70			
2. 14–17 years old	66	309.03			
3. 18–24 years old	85	290.11			
4. 25–30 years old	64	278.07			
5. 31–35 years old	106	344.60			
6. 36–40 years old	100	395.20	10	90.184	0.000
7. 41–45 years	120	442.30			
8. 46–50 years	98	475.35			
9. 51–55 years	60	483.77			
10. 56–60 years old	24	514.79			
11. Age 61 and over	10	526.25			

As can be seen in Table 5, there is a significant difference between the mean scores of awareness for reducing the ecological footprint according to age, and the calculated effect size was found to be very high ($X^2_{(10)}$ = 90.184; p = 0.000, $p < 0.05$; η^2 = 0.112). The results of the Mann-Whitney U Test, which was conducted to determine between which groups the significant difference was listed is in the following paragraph.

There is a significant difference with the participants aged 10–13 and 56–60, in favor of the participants aged 56–60, and the effect size is moderate (U = 280; Z = −2.775; $p < 0.05$; r = −0.34). There is a significant difference with the participants aged 14–17 and 41–45, In favor of the participants aged 41–45, and the effect size is moderate (U = 2664.5; Z = −3.689; $p < 0.05$; r = −0.30). There is a significant difference between the participants aged 14–17 and 46–50, in favor of the participants aged 46–50, and the effect size is moderate (U = 1921.5; Z = −4.403; $p < 0.05$; r = −0.34). There is a significant difference with the participants between the ages of 14–17 and 51–55, in favor of the participants aged 51–55, and the effect size is moderate (U = 1170.5; Z = −3.956; $p < 0.05$; r = −0.35). There is a significant difference between the participants aged 14–17 and 56–60, in favor of the participants aged 56–60, and the effect size is moderate (U = 397; Z = −3.605; $p < 0.05$; r = −0.38). There is a significant difference with the participants between the ages of 14–17 and 61 and above, in favor of the participants aged 61 and above, and the effect size is moderate (U = 163; Z = −2.567; $p < 0.05$; r = −0.30).

There is a significant difference with the participants aged 18–24 and 41–45, in favor of the participants aged 41–45, and the effect size is moderate (U = 3044.5; Z = −4.914; $p < 0.05$; r = −0.34). There is a significant difference with the participants aged 18–24 and 46–50, in favor of the participants aged 46–50, and the effect size is moderate (U = 2082.5; Z = −5.830; $p < 0.05$; r = −0.43). There is a significant difference with the participants between the ages of 18−24 and 51−55, in favor of the participants aged 51–55, and the effect size is moderate (U = 1344; Z = −4.843; $p < 0.05$; r = −0.40). There is a significant difference with the participants aged 18–24 and 56–60, in favor of the participants aged 56–60, and the effect size is moderate (U = 415; Z = −4.426; $p < 0.05$; r = −0.42). There is a significant difference with the participants between the ages of 18–24 and 61 and above, in favor of the participants aged 61 and above, and the effect size is moderate (U = 165.5; Z = −3.149; $p < 0.05$; r = −0.32).

There is a significant difference with the participants aged 25–30 and 41–45, in favor of the participants aged 41–45, and the effect size is moderate (U = 2207; Z = −4.748; $p < 0.05$; r = −0.35). There is a significant difference with the participants aged 25–30 and 46–50, in favor of the participants aged 46–50, and the effect size is moderate (U = 1528.5; Z = −5.510; $p < 0.05$; r = −0.43). There is a significant difference with the participants aged 25–30 and 51–55, in favor of the participants aged 51–55, and the effect size is moderate (U = 986.5; Z = −4.669; $p < 0.05$; r = −0.41). There is a significant difference with the participants aged 25–30 and 56–60, in favor of the participants aged 56–60, and the effect size is moderate (U = 313; Z = −4.265; $p < 0.05$; r = −0.45). There is a significant difference with the participants

between the ages of 25–30 and 61 and above, in favor of the participants aged 61 and above, and the effect size is moderate (U = 119.5; Z = −3.172; $p < 0.05$; r = −0.36).

Table 6 shows the findings for the comparison of the participants' awareness of reducing the ecological footprint by education level.

Table 6. Kruskal Wallis H Test results according to education level.

Level of Education	N	Xrow	df	x^2	*p*
1. Primary School	8	438.50			
2. Secondary School	55	374.57			
3. High School	110	358.98	4	2777	0.596
4. License	545	393.37			
5. Graduate	55	384.89			

As can be seen in Table 6, there is no significant difference between the mean scores of awareness about reducing ecological footprint according to education level ($X^2_{(4)} = 2.777$; $p = 0.596$, $p > 0.05$). It is a remarkable result that there is no significant difference and relationship in the awareness of ecological footprint reduction according to education level. This situation can be explained by the fact that subjects and/or studies related to ecology and ecological footprint are not adequately covered in educational institutions. As a matter of fact, the inclusion of content/studies on the development of behaviors towards reducing the ecological footprint of participants under the age of 40 in formal and non-formal education institutions, as well as in traditional learning tools such as television, may change this situation.

The findings regarding the comparison of the awareness of the participants to reduce the ecological footprint according to the place of residence are shown in Table 7.

Table 7. Kruskal Wallis H Test results by place of residence.

Living Place	N	Xrow	df	x^2	*p*
1. Village	49	365.95			
2. Town	14	377.71			
3. District center	163	385.45	3	0.541	0.910
4. City center	547	389.59			

As can be seen in Table 7, there is no significant difference between the mean scores of awareness of reducing the ecological footprint according to the place of residence ($X^2_{(3)} = 0.541$; $p = 0.910$, $p > 0.05$). It is an important finding that there is no significant difference or relationship in the awareness of reducing the ecological footprint according to the place of residence. It can be stated that this situation shows that there is no difference between rural and urban living conditions, and that individuals continue their lives with similar behaviors and habits under similar conditions in the production-consumption-distribution life network, even if the place of residence is a village or a city center.

3.3. Findings Regarding the Relationship between Ecological Footprint Reduction Awareness and Variables

In the present study, we tried to determine the relationship between the awareness of the participants to reduce the ecological footprint and gender, age, education level, and place of residence. In this context, the correlation results showing the relationships between the participants' awareness of reducing the ecological footprint and the chosen variables are shown in Table 8.

Table 8. Spearman Rank Differences Correlation results showing the relationships among the variables.

Variables	01	02	03	04	05
01. Ecological Footprint	1000	0.001	0.318 **	0.035	0.021
02. Gender		1000	0.116 **	0.031	0.024
03. Age			1000	0.439 **	0.216 **
04. Education Level				1000	0.245 **
05. Place of Residence					1000

** $p < 0.01$.

As can be seen in Table 8, there is a moderate and positive significant relationship between age and education level (r = 0.439), and moderately positive relationship between participants' awareness of reducing their ecological footprint and their age (r = 0.318). According to the results of the research, it has been revealed that there is a significant and moderate relationship between age and education level in the awareness of the participants to reduce the ecological footprint in line with the correlation values. Considering that age and education level are important factors in determining the level of having a profession and income, it becomes clear that these variables should be taken into account in raising awareness about reducing the ecological footprint and developing behaviors.

4. Discussion

In this study, aiming to reveal the awareness levels and behaviors of the participants towards reducing the ecological footprint by taking the personal consumption into account, which is the most important component of the ecological footprint, it has been determined that the carbon footprint and ecological footprint of the participants are similarly moderate. It should be emphasized that, while the average ecological footprint resulting from personal consumption was 1.7 gha in the present research, this result is the direct/primary footprint value. It is estimated that with the addition of indirect/secondary activities in the ecological footprint, the value will be much larger and even higher than the Turkey average (3.4 gha in 2018) [52]. In the world, the total of personal consumption in ecological footprint (gha per capita) according to the consumption categories of the demand is 2.26, food is 1.18, housing is 0.16, electricity is 0.10, personal transportation is 0.66, and clothing is 0.02 [5]. It can be stated that the size of the ecological footprint in Turkey is above the world average in personal consumption.

The carbon footprint average of the participants was at the level of damage, as in similar studies [62,63]. However, Turkey's biological capacity is 1.3 gha according to 2018 data [51]. When all these values are taken into account, it is seen that there is a significant biocapacity deficit in Turkey, in other words, there is ecological poverty. After 2007, more than 80% of the world's population lives in ecologically indebted countries as a result of the consumption exceeding the biocapacity [5]. In recent years, it has been pointed out that there is a rapid move away from sustainable life with increasing population and consumption, growing ecological footprint and decreasing biocapacity [64–66]. It is seen that the sustainable living goals cannot be achieved with the decisions and practices taken for sustainability with international agreements [31–33].

The ecological footprint and biocapacity status of countries are different from each other. While the average footprint of humanity causes an ecological deficit of 50% on a global scale, in some countries the ecological deficit is very high. For example, the biocapacity deficit, or ecological poverty, in the USA is 4.5 gha [52]. While the ecological footprint values of the countries vary, the amount of natural resources they use is also different. For example, people living in the USA use nine times more natural resources per capita than people living in India [17].

Similar to the rest of the world, the most increasing footprint in Turkey is carbon-based. The electricity sector has the largest share in the CO_2 emissions that make up the carbon footprint [67]. Electricity consumption in Turkey constitutes approximately 26% of the carbon footprint and 14% of the total ecological footprint [17,68]. The country with the

highest increase in carbon emissions compared to the 1990 levels is Turkey [5]. If the current situation in Turkey continues, it is estimated that the ecological footprint of consumption will increase by 63% and the biological capacity per capita will decrease by 64% until 2050 [5]. According to this scenario, the biocapacity gap in Turkey in the 2050s will increase by about 1.3 Earths (gha) compared to the 2020s. According to the scenario where business is carried out as usual on a global scale, it is predicted that humanity will need 2.8 Earths (gha) by 2050 to meet the demand for resources and land use [17].

It has been determined that there is a significant relationship between the carbon footprint of the participants and their age and education level. The carbon footprint increases with age. However, it has been revealed that the carbon footprint and ecological footprint increase as the income level and education level increase. The ecological footprint of the highest income group in Turkey is three times more than the footprint of the lowest income group [5]. It has been determined that the ecological footprint increases as the income level increases in the world as well [17]. Similarly, the footprint of food increases by 2.5 times and the footprint of transportation increases by 15 times while the total ecological footprint triples from the lowest income group to the highest income group [5]. The fact that subjects such as ecology and ecological footprint are not adequately covered in formal and non-formal education institutions can be shown as an important reason for the lack of ecological footprint awareness and ecological footprint reduction behaviors of educated individuals.

The results of the research show that there is a moderately significant difference in the effect size of the awareness of reducing the ecological footprint according to age, between the participants among the 10–30 age range and 40 and above, in favor of the participants over the age of 40. This result is not consistent with the result of individual behaviors in ecological footprint calculation. While the size of the ecological footprint increases as age increases, the awareness of reducing the ecological footprint seems to be high above the middle age (40 years and above). Within the scope of the research, it can be said that an awareness can be created above the middle age about raising awareness about reducing the ecological footprint in individuals. As a matter of fact, 79.7 percent of the participants answered "I got an idea about ways to reduce my ecological footprint with this study" after the scale application in the research. Considering this ratio, there was a significant relationship between age and having an idea about ways to reduce the ecological footprint ($X^2_{(20)}$ = 43.509; p = 0.002, $p < 0.05$). The last item given to the participants was "I will make an effort to reduce my ecological footprint." The rate of those who gave the positive answer is 91.5. This rate shows that all participants, regardless of age, tend to act with a consciousness to reduce their ecological footprint. In addition, it can be deduced that online studies and practices aimed at improving awareness, effort and behavior towards reducing the ecological footprint of participants under the age of 40 are not sufficient.

According to the place of residence (village, town, district center, city center) in the research, there was no significant difference in awareness and behavior towards reducing the ecological footprint. The similarity of daily life in rural and urban settlements and the gradual decrease in the difference between living conditions can be shown as an important reason for this situation. As a matter of fact, electrical technological tools and their use, access to food and transportation conditions in the homes of individuals have begun to resemble largely in rural and urban areas. The urban population in Turkey is 93.2% in 2021 [68], and the gradual decrease in the rural population also supports the results of the research. However, since 1961 (2022), the built-up area footprint in Turkey has increased by 15% [68]. The category results related to housing in the research are also consistent with this rate.

A significant relationship was found in terms of gender in the transportation and garbage categories that are taken into account in the calculation of the ecological footprint. Gender stereotypes may have an impact on the behavior that determines individual carbon and footprint according to the variables, and the relationship between transportation vehicles and garbage in Turkey. Women's taking on more roles and responsibilities, es-

pecially in kitchen and cooking, and the use of transportation vehicles by men [69] can be shown as an important reason for these results. The relationship between the place of residence and the use of food products produced in the immediate vicinity, the house and transportation vehicles used for shelter is also meaningful. This situation can be explained by the difference in life in rural and urban settlements in Turkey, and the intensity of agricultural activities in rural areas. Supporting the previous result that the carbon footprint increases as age increases, the relationship between age and the increase in individual consumption is again encountered. The relationship between the increase in the number of showers as the education level increases, the tendency to use organic products, the habit of consuming ready-made meals, the use of excessive transportation, the differentiation and diversification of the needs for shelter, is also noteworthy.

Considering the results of the research, the use of water, use of foodstuffs, transportation, home use, energy use, clothing use, and contribution to recycling have emerged as important categories that determine the individual carbon and ecological footprint. It has been seen in the research that the enforcement power of laws, energy, water and food consumption, recycling and transportation have an important place in awareness and behavior towards reducing the individual ecological footprint, and it has been revealed that these are the factors that affect the carbon/ecological footprint size the most. As with the incentives applied for energy-saving products [70], this research reveals that the enforcement power of laws and government incentives are one of the most important solutions in reducing the ecological footprint. In addition, it is an important result obtained in the research that some behaviors in water consumption develop positively according to the categories for reducing the ecological footprint. It has been observed that the awareness of "not leaving the water running while brushing teeth" [71,72], which is an example in the curricula and textbooks of many courses in Turkey, has turned into a positive behavior in a significant part of the participants in the research. However, the opposite is true for using water-saving products. The fact that government support and incentives for energy-saving products do not apply to water-saving products may be one of the main reasons for this situation. Understanding and recognizing the attitudes and behaviors of consumers, especially in food consumption, is beneficial for industrial practitioners and decision makers who are making efforts to make a transition to more sustainable food systems. The change in consumers' attitudes towards more balanced food consumption can be one of the sustainability drivers for all food chains and result in more sustainable energy use and the implementation of a farm-to-table strategy across the entire food chain [73].

It has been observed that the participants have significant behavioral deficiencies in the behaviors towards reducing the ecological footprint in terms of recycling, reusing the product by repairing, composting, wasting water, food and clothing, and excessive use of packaged products. While this is a very important problem, it is not a situation that can be solved only with individual conscious behaviors. Government support, public solutions and incentives are also included in the transformation of behaviors such as separating garbage, paying attention to producing less garbage, contributing to recycling, re-use and not wasting into a lifestyle [74–79] is of great importance. As a matter of fact, some of the participants in the study indicated the lack of recycling systems in their living areas as an important reason, even though they wanted to separate their garbage. It was determined that the participants did not have an idea about ecological practices such as composting. However, water, food and clothing waste emerged as a very important problem in all age groups in the present research. Studies on waste have also emphasized that education, social norms, and pro-environmental behaviors are important in preventing waste [74,77,80–87].

5. Recommendations

Since it was revealed in the research that the age and education level of the individuals were related to the awareness and behaviors towards reducing the ecological footprint, studies should be carried out in formal and non-formal education institutions and in

informal learning environments (such as the media) by taking this situation into account. Considering the research results in which the waste of water, energy, food and clothing is very high, there is also a need for legal regulations with high enforcement power on savings, waste and recycling. It is an important issue in reducing the ecological footprint of individuals, especially the upper income group, to avoid waste and turn to sustainable products. The power of individuals' lifestyles, consumption habits and behaviors in reducing the ecological footprint should not be ignored. The preferences of individuals for sustainable life should be directed, and they should be enabled to play an effective role in this regard by using the power to reduce the demand for the world's non-eternal natural capital and to keep it at a certain level by the choices they make. In addition, it will be useful to investigate the factors that affect attitudes and behaviors towards sustainable consumption in a negative way and later to discuss how these factors can be eliminated. Do not forget that there is only one WORLD for all of us!

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Appendix A

Carbon Footprint and Ecological Footprint Calculations have been made with the calculation tools and items used within the scope of the Climate Crisis Project [57]. Regarding the living conditions in Turkey, adaptations have been made based on the items in the Global Footprint Network [52]. Ecological footprint indicators have also taken into account in the study [58]. Calculation tool and survey items can be accessed from the link below: http://istanbulkadinmuzesi.org/banabirakacaginizgelecek/ekoloji-ayak-izi/, accessed on 1 August 2022.

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