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Research Article

# Paddy Farmers Adopting Climate Change Mitigation Methods

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## Abstract

This study aims to determine whether paddy farmers adopt greenhouse gas emission reduction methods in order to mitigate the effects of climate change. The main material of the study consists of primary data obtained from paddy farmers producing paddy in the provinces of Edirne, Samsun, Balıkesir, Çanakkale, Çorum and Sinop. In this context, a survey was conducted with 491 paddy farms according to the Simple Random Sampling Method. Descriptive statistics were used in the analysis of the data. The level of adoption was determined. According to the research findings, it was determined that the level of adoption of greenhouse gas emission reduction methods was low in the provinces where the study was conducted. However, the level of adoption of climate change reduction methods by farmers in Çanakkale province was higher than farmers in other provinces. It was determined that the level of adoption of climate change reduction methods varied according to the characteristics of farmers.
**Keywords:** climate change, greenhouse gas emissions, mitigation methods, adoption, paddy farms

## Çeltik Üreticilerinin İklim Değişikliğinin Etkisini Azaltıcı Yöntemleri Benimseme Durumu

## Öz

Bu araştırmada, çeltik üretimi yapan tarım işletmelerinin iklim değişikliğinin etkisini hafifletme konusunda işletme yöneticilerinin sera gazı emisyonunu azaltıcı yöntemleri benimseme durumunu belirmek amaçlanmıştır. Çalışmanın ana materyalini, Edirne, Samsun, Balıkesir, Çanakkale, Çorum ve Sinop illerinde çeltik üretimi yapan işletme yöneticilerinden elde edilen birincil nitelikli veriler oluşturmaktadır. Bu kapsamda Basit Tesadüfi Örnekleme Yönetimi'ne göre 491 çeltik işletmesi ile anket yapılmıştır. Verilerin analizinde tanımlayıcı istatistiklerden yararlanılmış olup, benimseme düzeyi hesaplanmıştır. Araştırma bulgularına göre, araştırmanın yapıldığı iller genelinde sera gazı emisyonunu azaltma yöntemlerini benimseme düzeyinin genel olarak düşük olduğu tespit edilmiştir. Ancak Çanakkale ilindeki işletme yöneticilerinin iklim değişikliğini azaltıcı yöntemleri benimseme düzeyi diğer illerdeki işletmelere göre daha yüksek olduğu ve işletme yöneticilerinin özelliklerine göre yöntemleri benimseme düzeyinin değiştiği tespit edilmiştir.
**Anahtar Kelimeler:** iklim değişikliği, sera gazı emisyonu, azaltıcı yöntemler, benimseme, çeltik işletmesi

## Introduction

Climate is defined as the average of temperature, humidity, wind, precipitation, atmospheric pressure and other meteorological events over a certain period of time. Changes in climate that are followed for long periods of time in comparable time periods and that directly or indirectly disrupt the composition of the global atmosphere as a result of naturally occurring climate change and human activities are called climate change (Ministry of Agriculture and Forestry, 2024). According to the definition of the European Statistical Office (2021), climate change refers to the effects of emissions of gases such as carbon dioxide ($CO_2$) and methane ($CH_4$) known as greenhouse gases, as a result of human-oriented (anthropogenic) activities, on climate, along with the increase in temperatures. Greenhouse gases consist of the sum of 7 gases that have a direct effect on climate change. Non-fluorinated gases are carbon dioxide (CO2), methane ($CH_4$), and nitrous oxide ($N_2O$), while fluorinated gases are; chlorofluorocarbons (CFC), hydrofluorocarbons (HFC), perfluorocarbons

(PFC), sulfur hexafluoride ($SF_6$) and nitrogen trifluoride ($NF_3$) (Organization for Economic Co-operation and Development (OECD), 2024; European Statistical Office (EUROSTAT), 2024). The shares of greenhouse gases in the atmosphere in 2021; Carbon dioxide ($CO_2$) has the largest share with 80.21%, followed by Methane ($CH_4$) with 11.34%, Dinatronoxide ($N_2O$) with 7.14% and finally Fluorinated Gases with 1.03% (TURKSTAT, 2024). When greenhouse gas emission rates are examined by sectors, according to 2021 figures, the energy sector comes first with 402.5 million tons, industrial processes and product use come second with 75.1 million tons, agriculture comes third with 72.1 million tons, and waste comes fourth with 14.7 million tons. There has been a 157.1% increase in greenhouse gases in sectors compared to 1990 (TURKSTAT, 2024). Therefore, it is possible to say that in parallel with the spread of agriculture, environmental concerns have emerged as a global problem and the agricultural sector is an important source of greenhouse gases and an important driving force for climate change (Balogh, 2020).

With the increasing world population, paddy, which is increasingly important as a staple food, has the largest cultivation area in the world after wheat and corn with a production area of 162 million hectares. On the other hand, paddy is a major source of greenhouse gas emissions with carbon dioxide ($CO_2$), methane (CH) and nitrous oxide ($N_2O$). Methane is the second most important greenhouse gas after carbon dioxide, and approximately 11.00% of methane emissions originate from paddy fields (Scholz et al. 2020). In Türkiye, paddy is the plant with the largest cultivation area after wheat, barley and corn in the cereal group, and cultivation areas continue to increase. When the last 30-year period is examined, the paddy cultivation area, which was 404000 da in 1991, increased by 220.53% in 2021 and reached 1.2 million da. In the last 20 years, the paddy cultivation area, which was 590 thousand da, increased by 119.48%. When the cultivation areas are examined on a provincial basis, Edirne ranks first with a share of 39.4% in the total cultivation areas. Edirne is followed by Samsun (15.7%), Balıkesir (13.1%), Çanakkale (9.0%), Çorum (6.1%) and Sinop (3.5%), respectively (TURKSTAT, 2024). Based on the data in question, the amount of greenhouse gas emissions originating from paddy production, which increases with the population in the world and in Türkiye, the risks it poses in terms of environmental destruction and the negative effects on climate change are the main problems of this research. The purpose of this article is to determine the level of adoption of methods to reduce the impact of climate change by the farmers of agricultural enterprises that produce paddy in Türkiye. As a result of the research, the hypothesis that the level of adoption of methods to reduce the impact of climate change by paddy enterprises varies geographically was tested.

## Materials and Methods

The research covers agricultural enterprises producing paddy in Türkiye. The research data are primary data. The data were obtained from face-to-face surveys conducted with paddy producers. The data obtained belong to the 2022-2023 production period. In addition, the research also utilized records from previous studies and institutions and organizations. The methods used in the research are grouped under 2 main headings: (i) the method used in collecting the research data, (ii) the method used in determining the level of adoption of methods to reduce the impact of climate change.

### Method Used in Collecting Research Data

The research data were obtained through a survey from agricultural enterprises producing paddy in the provinces of Edirne, Samsun, Balıkesir, Çanakkale, Çorum and Sinop. The number of enterprises surveyed was determined by simple random sampling method. The number of agricultural enterprises to be surveyed was calculated with the following formula (Yamane et al. 2001).

$$n = \frac{N(zS)^2}{Nd^2+(zS)^2} \quad (1)$$

The margin of error allowed from the average in the sampling process was taken as 10% and a confidence level of 95% was used. The optimum sample size was calculated as 491 using the formula given above. In determining which paddy farms to survey and the distribution of the paddy farms to be surveyed by province, the frame list of the agricultural farms engaged in paddy cultivation in the provinces constituting the research area and the random number table were used. First, 491 random numbers were generated using the random number table and the agricultural farms to be interviewed in the frame list were determined using these random numbers. Then, the distribution of the 491 paddy

farms determined as the farms to be interviewed by the random number table was determined by province. Accordingly, the number of paddy farms surveyed was 194 in Edirne, 105 in Samsun, 79 in Balıkesir, 62 in Çanakkale, 36 in Çorum and 15 in Sinop.

**Method Used to Determine the Level of Adoption of Climate Change Mitigation**

The level of adoption of methods to reduce the impact of climate change in the examined enterprises was determined by using the answers given by the paddy farm farmers to the questions in the survey prepared for this purpose. The research was based on Rogers' (1962) theory of diffusion of innovation. In the research, the stages of adoption were used in accordance with the suggestion of Rogers (1995) as (a) awareness, (b) interest, (c) evaluation, (d) trial and (e) adoption (acceptance or rejection). It was determined at which stage the examined agricultural enterprises were in adopting methods to reduce the impact of climate change. The level of adoption of methods to reduce the impact of climate change by the examined paddy farms was expressed with an index. In creating the index, economical water use, rainwater harvesting, reduced soil tillage, direct planting method, windbreak, environmentally friendly fertilization, combating agricultural drought, land consolidation, organic farming, good agricultural practices, agricultural insurance, use of bioenergy resources and carbon farming and agroforestry were taken as basis.

If the examined enterprises were implementing methods to reduce the impact of climate change, 1 point was given, and if they were producing traditional paddy, 0 points were given. The index that would express the level of adoption was found by dividing the current score received by the paddy producer by the maximum score that the producers could receive (13 points). In order for the paddy enterprises to be qualified as adopting methods to reduce climate change, the criterion of an index value of 0.5 and above was used.

Adoption index = (Total Score Received By The Farmer / Maximum Score The Farmer Can Receive) *100 (2)

**Results and Discussion**

**General characteristics of enterprises and farmers**

Within the scope of the research, the average land size allocated to paddy production in agricultural enterprises is 92.70 decares (Table 1). The average paddy cultivation area of agricultural enterprises producing paddy paddy in Vietnam is 7.3 decares (Khai and Yabe, 2011), and 1.5 decares in Northern Vietnam (Yen and Kamoshita, 2024), The average age of farm farmers is 50.63. The average age of farmers of agricultural enterprises producing paddy paddy is 47.15 in Nepal (Dhungana et al. 2004), 49 in the Göksu Delta (Polat and Dellal, 2016), 51 in Çanakkale (Semerci, 2023), and 48 in Ipsala (Avkıran and Yılmaz, 2023).

The average duration of education of farm farmers is 8.70 years, and 42.77% of the farm farmers are primary school graduates. The average education period of farmers of agricultural enterprises that include paddy production is 4.22 years in Nepal (Dhungana et al. 2004), 9 years in Ipsala (Avkıran and Yılmaz, 2023), 8.27 years in Çanakkale (Semerci, 2023), and 6.27 years in Vietnam (Khai and Yabe, 2011).

The average paddy experience of enterprise farmers is 25.52 years. The experience of farmers of agricultural enterprises that include paddy production in Vietnam is 19.50 years (Khai and Yabe, 2011). All of the enterprises have social security 79.02% of the farmers have social security from BAGKUR. The average annual income of enterprise farmers from non-agricultural sources is 181.018,17 TL (Table 1).

There is a difference between the provinces in terms of the age of the farm farmers, paddy cultivation experience and paddy cultivation area in the examined enterprises ($p<0.05$). The general characteristics of the farm farmers in Çanakkale Province differ from the farm farmers in other provinces.

The paddy land size, education and non-agricultural income of the farm farmers in Çanakkale Province are higher than the enterprises in other provinces ($p<0.05$). The enterprises in Çorum Province have the smallest farm land size. The age, education, paddy experience and non-agricultural income of the farm farmers in Sinop Province are lower than the enterprises in other provinces ($p<0.05$).

Table 1. General characteristics of enterprises and farmers by province

| Province | | Paddy land size (da) | Age (years) | Education (years) | Paddy experience (years) | Non-agricultural income (TL/year) |
|---|---|---|---|---|---|---|
| Edirne | Mean | 71.98[a] | 51.69[a] | 8.42[a] | 27.93[a] | 206.826,71[a] |
| | Standart deviation | 63.52 | 11.89 | 3.95 | 13.37 | 281632,35 |
| Samsun | Mean | 106.60[bc] | 50.74[ab] | 8.70[a] | 26.43[a] | 152.089,55[ab] |
| | Standart deviation | 83.63 | 12.76 | 4.51 | 15.35 | 191624,13 |
| Balıkesir | Mean | 111.88[bc] | 48.58[ab] | 9.01[a] | 25.07[a] | 203.550,00[ab] |
| | Standart deviation | 75.03 | 12.88 | 3.78 | 12.25 | 239.299,18 |
| Çanakkale | Mean | 142.12[b] | 45.56[b] | 9.43[a] | 11.98[b] | 294.769,23[ab] |
| | Standart deviation | 85.55 | 11.95 | 3.87 | 6.36 | 262182,55 |
| Çorum | Mean | 52.00[a] | 54.91[a] | 8.55[a] | 31.05[a] | 149.475,86[ab] |
| | Standart deviation | 42.29 | 11.12 | 4.10 | 17.47 | 172.277,42 |
| Sinop | Mean | 55.80[ac] | 57.40[a] | 7.93[a] | 33.00[a] | 94.971,43[b] |
| | Standart deviation | 68.92 | 12.14 | 3.53 | 17.23 | 10905,71 |
| Türkiye | Mean | 92.70 | 50.63 | 8.70 | 25.52 | 181.018,17 |
| | Standart deviation | 76.63 | 12.44 | 4.04 | 14.47 | 228101.94 |

[a,b,c] Values within a row with different superscripts differ significantly at P<0.05

**Determining the Level of Adoption of Climate Change Mitigation Methods**

Farmers' adoption of new technologies or measures for agricultural production processes is very important for adaptation to climate change (Nainggolan et al. 2023). Adoption of climate-friendly agricultural practices will increase the resilience and productivity of agricultural enterprises to climate change and reduce greenhouse gas emissions (Nyang'au et al. 2021). In this study, the methods to reduce the impact of climate change include; efficient water use, rain harvesting, reduced tillage, direct planting, windbreak, environmentally friendly fertilization, combating agricultural drought, land consolidation, organic farming, good agricultural practices, agricultural insurance, use of The status of adopting climate change mitigation methods by provinces of paddy farms in the study area is given in Table 2. The level of adoption of climate change mitigation methods by farmers in Çanakkale province is higher than farmers in other provinces and shows a statistical difference (p<0.001).

Table 2. Adopting methods to reduce climate change by province

| Province | Mean | Standart deviation |
|---|---|---|
| Edirne | 20.69[a] | 14.41 |
| Samsun | 24.76[a] | 16.49 |
| Balıkesir | 14.99[ad] | 15.91 |
| Çanakkale | 34.73[b] | 14.04 |
| Çorum | 4.91[c] | 6.40 |
| Sinop | 13.33[ad] | 7.94 |
| Türkiye | 21.03 | 16.20 |

[a,b,c] Values within a row with different superscripts differ significantly at P<0.05

Farmers' ability to adopt methods to reduce the impact of climate change depends on their awareness of these methods, their knowledge of the subject, their willingness to implement the method and their continuity in using the method. Farmers' climate change mitigation management; Agricultural insurance (74.5%), land consolidation (46.0%) and economical water use (40.9%) are among the methods with the highest adoption rate. These methods are among the methods that farmers have heard about, have knowledge about and tried the most. Windbreak (0.8%), carbon farm and agroforestry (0.8%) and rain harvesting (1.6%) are among the methods that have been heard about, have knowledge about and tried the least (Table 3).

New technologies, which are also accepted as the first condition of agricultural development in Türkiye, provide a social benefit when implemented by farmers. Therefore, every new technical information that has an application value should be quickly communicated to producers and efforts should be made to ensure their adoption (Kaya and Atsan, 2013). It will contribute to the adoption of new technologies and methods by ensuring that leading farmers see good practice examples both at home and abroad (Lasco et al. 2016; Kılıçtek and Aksoy, 2019; Eryılmaz et al. 2020).

In addition, the factors that motivate them to adopt climate change mitigation methods should be well understood. It is important for farmers to know the costs of these methods and to strengthen adoption by increasing farmer incomes (Aydın et al. 2017; Aryal et al. 2020). Another issue that

increases adoption is extension staff. When the individual extension method is preferred, a sense of mutual trust between the farmer and the extension staff is important. When the group extension method is preferred, it should be preferred that the extension staff is experienced (Eryılmaz et al. 2020).

Table 3. Implemanting climate change mitigation methods

| | **Awareness** | | **Interest** | | **Evaluation** | | **Trial** | | **Adoption** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Have you heard of it before?** | | **Do you have any information?** | | **Would you like to implement it after you have enough information?** | | **Do you?** | | **Will you implement it in the next production period?** | |
| | **Yes (%)** | **No (%)** | **Yes (%)** | **No (%)** | **Yes (%)** | **No (%)** | **Yes (%)** | **No (%)** | **Yes (%)** | **No (%)** |
| Efficient water use | 84.3 | 15.7 | 78.4 | 21.6 | 58.5 | 41.5 | 42.4 | 57.6 | 40.9 | 59.1 |
| Rain harvesting | 7.7 | 92.3 | 6.1 | 93.9 | 5.7 | 94.3 | 1.6 | 98.4 | 1.6 | 98.4 |
| Reduced tillage | 20.8 | 79.2 | 18.3 | 81.7 | 11.8 | 88.2 | 4.1 | 96.9 | 3.5 | 96.5 |
| Direct planting method | 30.3 | 69.7 | 24.6 | 75.4 | 10.4 | 89.6 | 4.5 | 95.5 | 4.5 | 95.5 |
| Windbreak | 10.6 | 89.4 | 6.7 | 93.3 | 3.1 | 96.9 | 1.0 | 99.0 | 0.8 | 99.2 |
| Environmentally friendly fertilization | 53.0 | 47.0 | 46.4 | 53.6 | 37.1 | 62.9 | 28.9 | 71.7 | 26.7 | 73.3 |
| Combating agricultural drought | 50.5 | 49.5 | 42.6 | 57.4 | 33.0 | 67.0 | 28.3 | 71.7 | 27.9 | 72.1 |
| Land consolidation | 96.7 | 3.3 | 91.0 | 9.0 | 82.3 | 17.7 | 66.8 | 33.2 | 46.0 | 54.0 |
| Organic farming | 90.2 | 9.8 | 78.4 | 21.6 | 37.5 | 62.5 | 11.0 | 89.0 | 9.0 | 91.0 |
| Good agricultural practices | 82.5 | 17.5 | 71.3 | 28.7 | 40.7 | 59.3 | 19.8 | 80.2 | 18.3 | 81.7 |
| Agricultural insurance | 97.8 | 2.2 | 95.5 | 4.5 | 91.2 | 8.8 | 79.8 | 20.2 | 74.5 | 25.5 |
| Use of bioenrgy resources | 20.0 | 80.0 | 18.1 | 81.9 | 6.3 | 93.7 | 12.2 | 87.8 | 11.0 | 89.0 |
| Carbon farming and agroforestry | 2.0 | 98.0 | 2.4 | 97.6 | 2.6 | 97.4 | 0.8 | 99.2 | 0.8 | 99.2 |

The adoption index was calculated to determine the level at which farmers adopted a method. Each variable adopting the methods in the research area was given a score between 0 and 1. After this score was converted into an index, all managers were divided into two subgroups according to the score they received: those who adopted at a high level and those who adopted at a low level.

The group of farmers with an adoption index of less than 50% was accepted as “low-level adopters” and the group of farmers with an index greater than 50% was accepted as “high-level adopters”. Almost all of the farmers were found to be low-level adopters (95.3%).

In Table 4, the effects of farmers' age, education and paddy production experience on the level of adoption of climate change mitigation methods were examined. There is a statistically significant difference between the age of farmers and the level of adoption of climate change mitigation methods ($p<0.05$). Young farmers have a higher level of adoption of climate change mitigation methods than older ones. As a result, it was determined that young farmers are aware of climate change mitigation methods, are interested in the subject, are willing to implement and are open to innovation.

When we examine whether the education factor affects farmers' adoption of climate change mitigation practices, it is found to be statistically significant ($p<0.05$). From this, it can be said that farmers with higher education levels also have higher adoption levels.

Accordingly, it was determined that the adoption level of farmers with less paddy production experience was high. The low level of consciousness and awareness of experienced farmers who have

been dealing with paddy for many years about climate change and their lack of willingness to learn should be evaluated by taking their current situation into consideration when developing policies on the subject.

Table 4. The effect of farmers' characteristics on the adoption of climate change mitigation methods

| **Adoption level** | **Frequency** | **%** | **Average age (years)** | **Standard deviation** |
|---|---|---|---|---|
| Low level | 468 | 95.3 | 51.02 | 12,48 |
| High level | 23 | 4.7 | 42.56 | 8,08 |
| Total | 491 | 100.0 | t:4.746 0.00<0.05 | |
| **Adoption level** | **Frequency** | **%** | **Average education (years)** | **Standard deviation** |
| Low level | 468 | 95.3 | 8.51 | 3,96 |
| High level | 23 | 4.7 | 12.39 | 3,88 |
| Total | 491 | 100.0 | t: -4.576 p:0.00<0.05 | |
| **Adoption level** | **Frequency** | **%** | **Average paddy experience (years)** | **Standard deviation** |
| Low level | 468 | 95.3 | 25.85 | 14,54 |
| High level | 23 | 4.7 | 18.69 | 11,10 |
| Total | 491 | 100.0 | t:2.971 p:0.006<0.05 | |

## Conclusions

The study examined the adoption of climate change mitigation methods by farmers in agricultural enterprises that produce paddy intensively in the provinces of Edirne, Samsun, Balıkesir, Çanakkale, Çorum and Sinop. Paddy farming is sensitive to the risk of climate change, which reveals the importance of paddy farmers adopting climate change mitigation methods. According to the research findings, the level of adoption of climate change mitigation methods by paddy farmers is quite low. When compared by province, it was determined that farmers in Çanakkale Province adopt climate change mitigation methods higher than other provinces. One of the most important factors in the dissemination of climate change mitigation methods is to reach the target audience with the most accurate and effective publication tools. Therefore, it can be suggested that inter-institutional coordination be strengthened between provinces while planning these publication activities. Another finding obtained from the research results is that producers should be aware of agricultural insurance, economical water use and land consolidation methods that will reduce the impact of climate change, and that training and publication activities on other methods (windbreak, carbon farm, agroforestry and rain harvesting) should be increased, again according to the research findings. On the other hand, it has been determined that the age of the farmer, paddy production experience and education are among the factors that positively affect the adoption status. The use of young and educated farmers' leadership qualities in the prepared training plans and programs can make these activities more effective.

Managers who do not have sufficient knowledge about the methods are late in adopting the methods. While determining policies regarding climate change adaptation measures, the level of farmers' adoption of methods that will reduce the impact of climate change should be taken into consideration.

In summary, policy makers should focus on awareness-raising activities on the impact of climate change on the agricultural sector and the impact of the agricultural sector on climate change before providing training and publication services on farmers' implementation of methods to reduce climate change. In this way, their knowledge about these existing methods will increase and their adoption will be strengthened. Similarly, increasing awareness and education will positively affect farmers' perceptions and acceptance of methods. Adoption of climate change mitigation methods is significantly related to farmers' general characteristics such as age, education level, income and experience, and farmers' perception of climate change. Adaptation strategies should be developed by taking into account not only farmers' characteristics but also the provinces where the enterprises are located. Local governments where the provinces are located should be part of the local development agenda to increase the effectiveness and sustainability of adaptation interventions to mitigation methods. Local governments should also allocate sufficient resources to prioritize climate change awareness.

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**Author Contributions**

The authors declare that they have contributed equally to the article.

**Conflicts of Interest**

The authors declare that they have no conflict of interest.

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