

Article

Crop Insurance, Land Productivity and the Environment: A Way forward to a Better Understanding

Agnieszka Kurdyś-Kujawska ^{1,*} , Agnieszka Sompolska-Rzechuła ² , Joanna Pawłowska-Tyszko ³
and Michał Soliwoda ⁴

¹ Faculty of Economics, Department of Finance, Koszalin University of Technology, Kwiatkowskiego 6E, 75-343 Koszalin, Poland

² Faculty of Economics, Department of Applied Mathematics in Economics, West Pomerania University of Technology Szczecin, Janickiego 31, 71-270 Szczecin, Poland; asompolska@zut.edu.pl

³ Director's Plenipotentiary for FADN, Institute of Agricultural and Food Economics, National Research Institute, Świętokrzyska 20, 00-002 Warsaw, Poland; joanna.tyszko@ierigz.waw.pl

⁴ Department of Finance and Risk Management, Institute of Agricultural and Food Economics, National Research Institute, Świętokrzyska 20, 00-002 Warsaw, Poland; michal.soliwoda@ierigz.waw.pl

* Correspondence: agnieszka.kurdys-kujawska@tu.koszalin.pl; Tel.: +48-94-3439-160

Abstract: Providing farmers with effective risk management tools and increasing the productivity of factors of production, while limiting negative effects on the environment, is an important challenge for the current EU agricultural policy. The aim of this research is to identify and evaluate the relationship between crop insurance and land productivity in the context of environmental effects. The study covered farms with crop insurance participating in the Polish FADN system. The article uses the TOPSIS method of organizing objects. We classify farms in terms of land productivity and examine the relationship between these results and the value of insurance coverage. In our conceptual and empirical framework, we recognize that there is a mutual relationship between crop insurance, land productivity and the environment. Our empirical results show that the level of insurance coverage may support the increase in land productivity, indirectly affecting the environment. Farms with the highest productivity level were characterized by an average value of insurance that was double that compared to farms with the lowest productivity level.

Keywords: crop insurance; land productivity; environment; TOPSIS method; Poland



Citation: Kurdyś-Kujawska, A.; Sompolska-Rzechuła, A.; Pawłowska-Tyszko, J.; Soliwoda, M. Crop Insurance, Land Productivity and the Environment: A Way forward to a Better Understanding. *Agriculture* **2021**, *11*, 1108. <https://doi.org/10.3390/agriculture11111108>

Academic Editor: Piotr Prus

Received: 8 September 2021

Accepted: 31 October 2021

Published: 6 November 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Today, farmers have to cope with many challenges, which due to their social, environmental and economic context, often contradict each other. In the economic and social dimension, the basic goal of a farm's operation is to maintain business continuity, further development and ensure a decent income for its owners [1]. In the environmental context, it is taking actions aimed at achieving sustainable agricultural development, which is associated with the implementation of resilient agricultural practices that support synergy between increasing productivity and maintaining ecosystems capable of providing specific services [2]. As agricultural producers face the inherent threats of climate change, they employ various risk management strategies to reduce uncertainty, including crop insurance [3].

Crop insurance has long been considered one of the main drivers of structural change in agriculture. Crop insurance contributes to the improvement and stabilization of the production results of farms [4], leads to an increase in productivity [5,6], inter alia, by undertaking risky agricultural practices [7]. Despite this, crop insurance can also have serious economic, social and environmental consequences [8]. It should be noted that global agricultural production is currently unsustainable [9]. Global land-use change, mainly due to the expansion and intensification of agriculture, has resulted in widespread

biodiversity decline, 74% of the earth's surface degradation [10], land deforestation, water degradation [11] and significant greenhouse gas emissions [12]. As a consequence of these activities, serious climate changes occur, which will increase the demand for insurance and/or increase the amount of compensations paid. They will also influence “what” can be produced, “when” it can be produced and “how much” can be produced [13]. Climate change has a direct and indirect impact on agricultural production. With increased variability of weather conditions and more frequent episodic weather events temperature changes and water availability will have a direct impact on yields [14] and thus on productivity [15]. Rising temperatures increase ozone formation in the troposphere, and increased ozone levels cause oxidative stress in plants, limiting photosynthesis and plant growth [16]. Climate change affects the decline in the population of plant pollinators, which may have multiple effects on agricultural production [17,18]. Climate change also increases crop losses and damage caused by pests, pathogens and weeds [19].

Research to date on determining the relationship between crop insurance, land productivity and the environment has yet to use its potential to systematize our understanding of these processes. In this context, the aim of our research is to identify and assess the relationship between crop insurance and land productivity in the context of environmental impacts. In particular, we want to find out if there is a relationship between crop insurance and land productivity, which is determined, *inter alia*, by the use of specific agricultural practices that may have a negative impact on the environment. We assume that the farmer can choose to accept certain practices or not because he is insured; likewise, he may or may not take out insurance because he uses certain practices that affect the state of the environment. The relationships between crop insurance, productivity and the environment are summarized in Figure 1. The figure below shows a schematic illustration of the cause and effect relationship of crop, productivity and environmental insurance. On the one hand, crop insurance determines higher productivity; on the other hand, higher productivity is a factor determining the use of insurance in farms. In turn, the environment, and more specifically environmental changes, results from the application of specific practices that increase productivity. Environmental changes are not without significance for achieving higher productivity in the future and the need for greater protection of production.

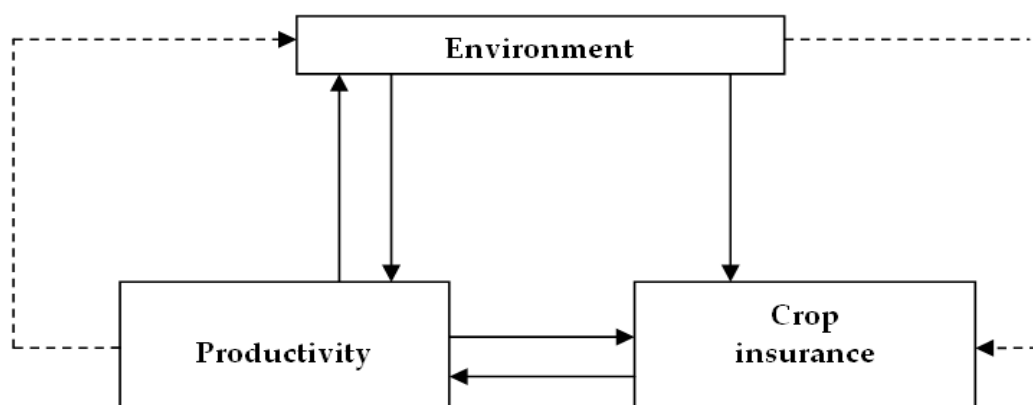


Figure 1. Crop insurance, productivity and the environment—a conceptual model.

This study focuses on the relationship between crop insurance and the level of land productivity, considering the simultaneity and interdependence of decisions about the level of insurance and the intensity of use of the productive resource, which is land, and their environmental impact. As the agricultural sector implements measures to adapt to or deal with climate variability and change, the potential negative consequences of these measures should be explored to avoid increased sensitivity or (unintended) environmental impacts [20]. In this context, we contribute to the international literature that tries to identify and assess the environmental consequences of insurance.

It should be noted that one of the main challenges faced by policymakers in all countries in the world is how to meet the growing demand for food and what risk management methods to promote while avoiding the depletion of natural capital, which is the basis of social welfare [21]. The article is organized as follows. First, the literature on the importance of agricultural productivity and crop insurance on environmental effects in agriculture is briefly presented. Secondly, the research method and the process of selecting variables as well as the research material are presented. The results section presents the main findings of the research. In the discussion, the results of the research were compared with other findings in this field. Finally, conclusions and implications for policy makers are presented.

Literature Review

Productivity in agriculture is a measure of resource efficiency in the production process. It allows one to assess the final effect of activities undertaken on the farm based on the resources available [22]. Farm resource productivity is important in view of the global challenges facing agriculture today, including food security and poverty, climate change adaptation and mitigation, natural resource degradation and depletion and increased farm incomes. As pointed out by Ozkan et al. the work of [23] relates to productivity, which refers to the best possible allocation of resources included in the production system, in other words, it is the sum of technical efficiency and resource allocation efficiency. Productivity gains reflect an increase in the efficiency of production processes and is an important mechanism for generating higher farm income, leading to increased social welfare. Land productivity is assigned an important role in sustainable development, but higher productivity is also accompanied by “side effects” causing environmental damage, mainly as a result of intensive land use, biodiversity depletion, high specialization, high doses of plant protection products and fertilizers. Productivity is an issue of great interest to researchers from many countries. Productivity is assessed in various contexts: in relation to various production factors, in a time system or in a comparative system [24]. Productivity, however, is not only determined by inputs. The efficiency of processing inputs into production is influenced by external conditions, and in agriculture, these conditions can be divided into natural conditions, such as weather and climate, social conditions, such as relationships, behaviors and attitudes, [25] and economic conditions, including, inter alia, access to capital, agricultural insurance systems, agricultural subsidies, structure and the level of prices.

The development of the agricultural insurance market has a positive impact on the increase in productivity [26]. At the same time, the resources of farms (land, labor, capital) determine whether they have insurance. This is suggested by previous studies which proved that agricultural production, farm income, level of profitability, return on equity, cash flow, land structure, yields or the value of fixed assets have an impact on farmers’ decisions to purchase insurance (see: [27]).

Tahamipour et al. [6], by examining the factors determining productivity in the Iranian agricultural sector, showed that crop insurance has a positive effect on the productivity of agricultural factors of production. By paying risk management premiums, farmers increase the degree of productivity by allocating resources more appropriately and investing in more risky and productive activities. Pawłowska-Tyszko and Soliwoda [28] analyzed the impact of agricultural insurance on the economic and financial sustainability of farms in Poland and proved that the productivity of land in farms insuring crops was higher than in farms without insurance. This may indicate that insurance may contribute to the improvement of land productivity, and thus—an increase in the level of income. Gross value added that is related to labor inputs informing about labor productivity and the ability to generate income in farms was also higher in farms with insurance. This may mean that farms that insure their crops use their labor resources much more effectively, which may be associated with greater possibilities for limiting costs for restoration of agricultural production in the perspective of the possessed security in the form of insurance. The value of the return on equity ratio and the value of the debt ratio suggest that farms with insurance

are able to effectively use their capital, and they are also willing to take on more risky activities in terms of shaping the capital structure. Sihem [26], by assessing the relationship between agricultural insurance and productivity in 23 American and European countries, proves that the penetration of the agricultural insurance market may be conducive to an increase in land productivity by considering crop risk management. Kurdyś-Kujawska and Sompolska-Rzechuła [29], analyzed the impact of insurance on the development of farms in the central Pomeranian region of Poland, and they showed that insured farms were characterized by a higher average share of own land in the structure of agricultural land, compared to uninsured farms. On these farms, land lease was also of great importance, thanks to which farmers could increase the production potential of the farm and adapt production to the effective demand on the market. In addition, farms with insurance had better access to financial services, meaning they could engage in more risky activities (e.g., increasing investments, changing the way production is organized, etc.). Compared to other units, the insured farms increased the area of agricultural land, which was associated with an increase in agricultural income, economic efficiency and productivity and labor efficiency. This is because insurance stabilizes your income by paying compensation for insured losses. A stable income is often a prerequisite for receiving a financial loan and investing. By having insurance, farm managers are able to adjust their production strategies and thus improve economic performance [4]. Hazell [30] argues that farmers can allocate resources to the maximum extent if they are confident that they will be compensated for significantly lower income for reasons beyond their control. In addition, they can develop more profitable crops, even if they are risky, and use better but uncertain technology when they are compensated in the event of a loss.

Insurance, similar to productivity, is assigned an important role in the sustainable development of agriculture. The condition for achieving sustainable development is the stability and financial security of economic entities that enable uninterrupted operation. Insurance has a positive impact on individual elements of sustainable development, i.e., social, economic, environmental and institutional and political order [31]. Particular importance is attached to insurance in achieving farm stabilization by reducing the uncertainty of operation, maintaining the financial liquidity of the farm, ensuring profitability and stabilization of income. Insurance may also have a negative impact on the environment, as shown by previous research. For example Claassen et al. [32] indicated that crop insurance affects land use change and crop choices. As evidenced by Ren et al. [33] and Wang et al. [34] the productivity, efficiency and profitability of agriculture are closely related to the size of the farm. The consequences of increasing UAA in farms can be observed in many negative environmental effects, such as air and water pollution [35]. In addition, as the farm size grows, specialization increases mainly in the cultivation of cereals and livestock grazing and a shift away from permanent crops, grain-eating animals or mixed agriculture [36]. Greater land specialization and polarization will actually increase yields and input use efficiency, but at the same time drives many small and medium-sized farms out of the market and results in land abandonment and production decline in many different areas [37]. The increase in the degree of farm specialization, irrespective of the economic benefits resulting from a larger scale of production, its quality and higher prices, has negative effects on agriculture, such as increased market and production risk, uneven use of labor and incomplete use of land. It also leads to a reduction in biodiversity and an infringement of the ecological balance. Increasing the degree of specialization of farms is most often associated with an increase in the level of production intensity, which in turn leads to a harmful burden on the natural environment [38].

Walters et al. [39] suggested that crop insurance affects the allocation of acreage. Changes in land use and crop structure under insurance can lead to unforeseen side effects on environmental quality. Converting grassland to crop production could mean an increased use of fertilizers, pesticides and other chemicals in sensitive areas, potentially leading to additional runoff and water pollution. Shifts in crop mix towards more erosive and chemically intensive crops can also lead to increased runoff, leaching and water

pollution [40]. Weber et al. [41] indicated that crop insurance can lead farmers to take more risks, grow crops in erodible soils or specialize in fewer crops, thereby increasing the environmental spill-over effects of agriculture. Goodwin et al. [42] indicated that crop insurance results in the conversion of a significant amount of land into arable land. These practices can increase the damage to surface water, loss of nutrients and carbon dioxide in the soil. Cai et al. [43] suggested that crop insurance leads to riskier farming practices with potential food security implications. A similar opinion is expressed by Summer and Zulauf [44], who, analyzed the environmental consequences of subsidized crop insurance and found that insurance subsidies affect the environment through several channels. These included an incentive to expand into more environmentally sensitive areas, and to use more inputs such as average return, changes to crops that may have more negative environmental consequences and fewer risk-reducing practices. Chakir and Hardelin [45] showed that crop insurance changes the amount of chemicals used by farmers. Farmers also achieve higher land productivity thanks to the use of fertilizers and plant protection products. Fertilizers are the main inputs used to achieve high and quick rates of return from agriculture [46]. Increasing the input of mineral fertilizers increases production per hectare, and thus it intensifies agricultural production, as it increases production per unit of land and possibly also per unit of work [47]. A study by Lin et al. [48] showed that intensive production is associated with a transition from a state of high diversity (in terms of crop species and genetic varieties) over time and space to monoculture. In addition, as production intensifies, there is a shift from locally adapted varieties to high-yielding, high-input varieties, where the nutrient and water requirements of the new variety are often higher than that available in the wild. Thus, the intensive use of synthetic fertilizers and pesticides leads to soil degradation and environmental pollution in several agroecosystems, which has an adverse effect on humans, animals and aquatic ecosystems [49]. Production intensification is one of the key drivers of the loss of biodiversity and ecosystem services [50], as well as climate change [51].

Möhring et al. [52], based on the analysis of the relationship between crop insurance and pesticide use in French and Swiss agriculture, proved a statistically and economically significant relationship between crop insurance and the use of pesticides. In both countries, crop insurance was associated with the selection of more intensive crops with a higher pesticide consumption. In the case of France, it was found that crop insurance was also associated with a higher pesticide intensity per hectare. Insurance coverage may also lead to the cultivation of crops on land where the cultivation was previously too risky, for example due to poor growing conditions, natural hazards or high pest pressure. Growing crops on such land leads to a greater use of inputs and the use of pesticides. In turn, Deryugina and Konar [53] showed that crop insurance might induce farmers to use more water per unit area, reducing their water-use efficiency. It is also possible that the terms of the insurance contract could lead to an increase in water abstraction for a certain type of crop and a fixed area.

2. Materials and Methods

2.1. Methods

The TOPSIS (*Technique for Order Preference by Similarity to an Ideal Solution*) method was used to analyze the collected material related to agricultural productivity. Productivity of agriculture is a complex phenomenon characterized by many features, for its evaluation one can use the methods of multidimensional comparative analysis, including the methods of linear ordering of objects. The classical TOPSIS method was first presented by Hwang and Yoon [54] and is the most established technique for solving multicriteria decision-making (MCDM) problems. TOPSIS was further developed by Yoon [55] and also Hwang et al. [56]. The TOPSIS method is a reference method and consists of calculating the Euclidean distances of each assessed object from both the pattern and non-pattern development. The reference to the pattern and anti-pattern distinguishes it from the Hellwig's method, which is often used in ordering multi-feature objects but it only considers

the distances from the development pattern [57]. The TOPSIS method is very useful in constructing the ranking of objects described by many variables. It is based on the distances of objects from ideal solution and the anti-ideal solution [58]. TOPSIS has been widely applied to many fields with good results, such as finances, sustainable development, logistics, agriculture, poverty and quality of life. The aim in the paper of Bulgurcu [59] was to propose a multicriteria decision-making model to measure and compare the financial performance of thirteen technology firms trading on the Istanbul Stock Exchange. These firms are examined and assessed in terms of ten financial ratios, which are combined to obtain a financial performance score by using the TOPSIS method. The aim of the study of Bhutia and Phipon [60] was to develop a methodology to evaluate suppliers in supply chain cycle based on TOPSIS method. The authors have taken into consideration some important criteria which affect the process of supplier selection, that is, product quality, service quality, delivery time and price. Nowak et al. [61] assessed the level of sustainability in agriculture in 28 member states of the European Union with TOPSIS method. The analysis made it possible to develop a ranking of EU member states according to a differentiated level of measures and assign them to one of four groups characterized by different levels of sustainability in agriculture. The paper of Baral and Behera [62] that used the fuzzy TOPSIS method on agricultural farming for optimal allocation of different crops by considering the maximization of net benefit, maximization production and maximization utilization of labor. In the paper of Džunić et al. [63] the TOPSIS method was applied for the ranking of the types of social enterprises according to the employment of socially excluded categories. The research is based on data on the employment of marginalized groups, derived from a unique dataset collected by a survey of social enterprises in Serbia. The results indicated that enterprises for employment of persons with disabilities, citizens' associations and cooperatives in Serbia contribute the most in integrating the socially excluded. The TOPSIS method consists of the following steps.

Step 1. Selection of variables on the complex phenomenon.

The selection of features is made on the basis of content-related and statistical analysis [64]. One of the ways to statistically reduce the number of features describing the phenomenon under study is the variability analysis. Variables characterized by low variability are eliminated from the set of diagnostic variables because they ineffectively discriminate between objects. In the next step, the matrix of correlation coefficients between features is examined in terms of the strength of dependence. Over-correlated features should be eliminated from the original set of features because they carry the same information.

Step 2. Determination of the impact direction of variables in relation to the complex phenomenon.

The set of diagnostic features is the basis for further analysis, in which the nature of the features should be determined, i.e., stimulants; stimulants and nominants should be distinguished. The stimulant is a feature where a higher value indicates a better condition of the object in a given context. While the destimulant is a feature where lower values mean a better situation of the object in a given respect. Nominations are the type of variables that are stimulants in one range of a variable and stimulants in another. Desirable (optimal) values should be defined for the nominants.

Step 3. Normalization of the variable values.

There are many ways to normalize the features [65]. For the normalization in this paper the zero unitarization procedure was applied based on the following formula:

$$z_{ij} = \frac{x_{ij} - \min_l x_{lj}}{\max_l x_{lj} - \min_l x_{lj}} \left(\max_l x_{lj} \neq \min_l x_{lj} \right) \quad (1)$$

where z_{ij} is the standardized value of the j -th feature ($j = 1, 2, \dots, k$) for the i -th object ($i = 1, 2, \dots, n$), k is the number of the feature and n is the number of the object.

Max–min normalizations are useful for relative comparison between alternatives, i.e., a normalized value provides either the distance from the best candidate (benefit criteria) or from the worst candidate (cost criteria). This technique provides normalized values by linear transformation and keeps relationships between original data [65].

Step 4. Determine the positive-ideal (PIS) and negative-ideal (NIS) solutions.

The values of positiveideal (A^+) and negativeideal of development (A^-) are defined as the following:

$$A^+ = \left(\max_i(z_{i1}), \max_i(z_{i2}), \dots, \max_i(z_{ik}) \right) = (z_1^+, z_2^+, \dots, z_k^+) \quad (2)$$

$$A^- = \left(\min_i(z_{i1}), \min_i(z_{i2}), \dots, \min_i(z_{ik}) \right) = (z_1^-, z_2^-, \dots, z_k^-) \quad (3)$$

If zero unitarization is used as the normative formula:

$$z^+ = (\underbrace{1, 1, \dots, 1}_k) \quad z^- = (\underbrace{0, 0, \dots, 0}_k) \quad (4)$$

Step 5. Calculating the distance of all alternatives to the PIS (A^+) and the negative ideal (A^-) solution, using the Euclidean distance:

$$d_i^+ = \sqrt{\sum_{j=1}^k (z_{ij} - z_j^+)^2}, \quad d_i^- = \sqrt{\sum_{j=1}^k (z_{ij} - z_j^-)^2}, \quad i = 1, 2, \dots, n \quad (5)$$

Step 6. Determination of the value of a synthetic measure [66]:

$$\mu_i = \frac{d_i^-}{d_i^+ + d_i^-} \quad (6)$$

where in $0 \leq \mu_i \leq 1$, $i = 1, 2, \dots, n$, μ_i lies between 0 and 1 and the higher value corresponds to better performance.

Step 7. Linear ordering of an object and identification of developmental types.

After ordering the value of the aggregate feature, four classes are determined based on the arithmetic mean and the standard deviation calculated from its values:

- class I: $\mu_i \geq \bar{\mu} + s_\mu$ —very high level
- class II: $\bar{\mu} \leq \mu_i \leq \bar{\mu} + s_\mu$ —high level
- class III: $\bar{\mu} - s_\mu \leq \mu_i \leq \bar{\mu}$ —medium level
- class IV: $\mu_i < \bar{\mu} - s_\mu$ —low level

where: $\bar{\mu}$ is the arithmetic mean and s_μ is the standard deviation of the value of the synthetic feature.

The selection of an appropriate normalizing formula has a great impact on the results of the linear ordering of objects. It is recommended to choose formulas that give stable or almost-stable ranges of variability of the normalized variables. In the third step of the procedure to normalize the variables, an approach called zeroed unitization or linear max–min was used. In the literature on the subject, there are many proposals for the methods of normalizing variables [65,67]. Normalization formulas should meet the following postulates [67]:

1. Deprivation of titers (units) in which the diagnostic features are expressed;
2. Reduction of the order of magnitude of diagnostic variables to the state of comparability, which means equalizing the ranges of variability of features and, consequently, the possibility of adding them;

3. Equality of the spread of the ranges of variability of the values of all standardized features (range constancy) and the equality of the lower and upper limits of their range of variability, in particular it concerns the interval [0, 1];
4. The possibility of normalizing diagnostic features with positive, negative or only negative values;
5. The possibility of standardizing features taking the value of zero;
6. Non-negative value of standard features;
7. The existence of simple formulas—within a given normalization procedure—unifying the nature of the variables.

Standardization according to formula (1) ensures that all of the above-mentioned postulates are met, including, as the only one, the third postulate.

2.2. Materials

The examined objects were farms participating in the Polish FADN system, which in 2014–2018 had a crop insurance policy. The surveyed group consisted of 223 farms. They were mainly large farms with over 20 ha of agricultural land and farms specializing in field crops and mixed farms. The structure of agricultural holdings by agricultural land area and production type is presented in Tables 1 and 2.

Table 1. Structure of farms by utilized agricultural area.

The Utilized Agricultural Area (ha)	Number of Farms	%
Very small (UAA < 5)	0	0.00
Small (5 < UAA < 10)	6	2.69
Small-medium (10 < UAA < 20)	44	19.73
Medium-large (20 < UAA < 30)	24	10.76
Large (30 < UAA < 50)	64	28.70
Very large (UAA > 50)	85	38.12

Table 2. Structure of farms by type of farming.

Type of Farming	Number of Farms	%
Field crops	128	57.40
Other permanent crops	3	1.35
Milk	10	4.48
Other grazing livestock	4	1.79
Granivores	12	5.38
Mixed	66	29.60

The diagnostic variables adopted for the study were quantitative. The selection of variables was based on the available database and the analysis of research to date in the field of agricultural productivity (Table 3).

Table 3. Diagnostic variables accepted for the study.

No	the Name of the Variable
1	Labor profitability (PLN/AWU).
2	The share of arable land in the total UAA (%).
3	Soil carbonation index.
4	Herfindahl index (0, 1; where: 1-production specialization).
5	Share of leased land in the UAA (%).
6	Value of land, permanent crops and production quotas per 1 ha of UAA (PLN/ha).
7	Income from a family farm per 1 ha of UAA (PLN/ha).
8	Total output value per 1 ha of UAA (PLN/ha).
9	Value of fixed assets per 1 ha of UAA (PLN/ha).
10	Value of fertilizers per 1 ha of UAA (PLN/ha).

Table 3. *Cont.*

No	the Name of the Variable
11	Value of plant protection products per 1 ha of UAA (PLN/ha).
12	Cash flows from operating activities per 1 ha of UAA (PLN/ha).
13	Payments for operating activities per 1 ha of UAA (PLN/ha).
14	Gross value added per 1 ha of UAA (PLN/ha).

3. Results

In the first stage of the study, the variables were statistically analyzed in terms of their variability and relationships. All features were characterized by a strong variability—over 10%. In the next step, Hellwig’s parametric method of selecting features [57] was used and the variables strongly correlated with other variables were excluded from the set of diagnostic features. The following set of features presented in Table 4 was adopted as the final set of diagnostic variables, which constitute the basis for further research.

Table 4. The final set of diagnostic variables accepted for the study.

Variable	the Name of the Variable
X ₁	The share of arable land in the total UAA (%).
X ₂	Soil carbonation index.
X ₃	Herfindahl index (0, 1; where: 1-production specialization).
X ₄	Share of leased land in the UAA (%).
X ₅	Income from a family farm per 1 ha of UAA (PLN/ha).
X ₆	Total output value per 1 ha of UAA (PLN/ha).
X ₇	Value of fixed assets per 1 ha of UAA (PLN/ha).
X ₈	Value of plant protection products per 1 ha of UAA (PLN/ha).
X ₉	Cash flows from operating activities per 1 ha of UAA (PLN/ha).
X ₁₀	Payments for operating activities per 1 ha of UAA (PLN/ha).

Table 5 presents the values of descriptive parameters for the variables concerning land productivity in farms.

Table 5. Descriptive statistics for land productivity variables.

Variables	Mean	Median	Min	Max	Variation Coefficient	Skewness
X ₁	94.48	98.73	5.34	166.43	15.04	−1.67
X ₂	1.06	1.08	0.31	1.75	25.97	−0.20
X ₃	0.58	0.54	0.28	1.00	27.65	0.86
X ₄	23.33	17.88	0.00	136.02	99.86	1.11
X ₅	1756.60	1724.81	−36,738.31	13,253.12	185.17	−7.36
X ₆	5955.81	4961.59	−3289.97	30,811.42	63.55	2.25
X ₇	43,342.00	37,860.75	995.17	224,813.12	57.72	2.69
X ₈	387.15	336.07	0.00	3236.02	81.74	4.67
X ₉	3395.35	2789.63	−400.27	32,448.20	84.30	5.61
X ₁₀	1733.15	1632.04	876.30	6471.77	38.78	3.10

All variables are characterized by strong or very strong volatility, from 15.04% for X₁ to 185.17 for X₅. The distributions of most variables are characterized by strong right-hand asymmetry. Three variables X₁, X₂ and X₅ show left-hand asymmetry. The value of the crop insurance premium (X₁₁) is also characterized by a strong asymmetry and variability (skewness at 6.54 and variation coefficient at 156.79). Figure 2 shows the distribution of selected variables and the value of the crop insurance premium (X₁₁).

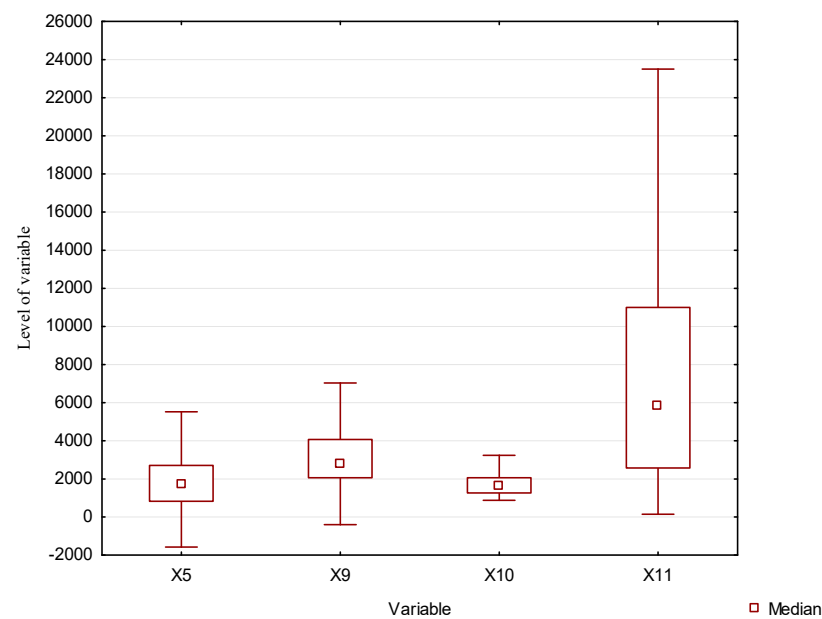


Figure 2. Distributions of selected variables and the value of the crop insurance premium.

In the next stage, the values of the variables were normalized by the method of zeroed unitarization, after which all the values of the variables are in the range from 0 to 1. Based on the normalized values of the variables, the distance of each farm of the standard and anti-standard was calculated. Then, using the TOPSIS method, the values of the synthetic measure of land use were calculated as the basis for the identification of four classes of farms in terms of land productivity (Table 6).

Table 6. Characteristics of farm classes in terms of land productivity.

Group	Number of Farms	Mean Value of the Synthetic Variable	Level of Productivity
All farms	223	0.365	-
I	36	0.421	Very high
II	82	0.379	High
III	73	0.347	Medium
IV	32	0.306	Low

The first class, in which 16% of farms are located, is characterized by the highest average value of the synthetic measure among all classes. The classes of these farms are distinguished by the best situation in terms of land productivity. The mean values of nine features out of all ten have the highest level. In this class, the average total production value per 1 ha of UAA (X_6) is 1.5 times higher than the value for all farms. The value of fixed assets per 1 ha of UAA (X_7) exceeds the average value of all farms by 36%. The fourth class, covering slightly more than 14% of farms, is characterized by the lowest average values of all the characteristics of agricultural productivity. The average value of plant protection products per 1 ha of UAA (X_8) is at a very low level—almost two times lower than the overall average. The average values of the features for all researched farms and the selected classes are presented in Table 7.

Table 7. Average values of the features for all researched farms and the distinguished classes.

Variables	Groups				
	All Farms	I	II	III	IV
X ₁	94.48	98.13	97.65	95.42	80.14
X ₂	1.06	1.20	1.18	1.02	0.72
X ₃	0.58	0.71	0.61	0.52	0.49
X ₄	23.33	27.90	25.03	22.01	16.82
X ₅	1756.60	1732.45	1877.01	1915.11	1113.59
X ₆	5955.81	9107.92	6310.26	4946.10	3804.78
X ₇	43,342.00	58,815.40	44,142.18	38,249.64	35,500.91
X ₈	387.15	514.09	434.23	360.22	185.14
X ₉	3395.35	5888.87	3184.60	2859.45	2352.72
X ₁₀	1733.15	2049.47	1725.07	1634.06	1624.05

In the next step of the analysis, the average value of crop insurance premium in individual classes was checked; the results are presented in Table 8.

Table 8. The level of land productivity and the average cost of crop insurance.

Group	Number of Farms	Level of Productivity	Value of Insurance (PLN)	Average Value of Crop Insurance Premium Per Farm (PLN)
All farms	223	-	2,224,621.20	9975.88
I	36	Very high	450,263.88	12,507.33
II	82	High	863,464.92	10,530.06
III	73	Medium	702,238.83	9619.71
IV	32	Low	208,654.08	6520.44

The second class, covering 82 farms (37%), is characterized by the highest sum of crops insured, which constitutes 39% of the total sum insured. Farms in this class are characterized by a high level of land productivity. In the first class, covering 36 farms (16%), the highest level of agricultural productivity was recorded with a 20% share in the total sum insured. A fairly high sum of insured crops was observed in the group of farms included in the third class (33% of farms). The sum insured in this case amounts to almost 32% of the total sum insured with the average level of land productivity. On the other hand, the fourth class (14% of farms) with the lowest level of land productivity is characterized by the lowest percentage relating to the sum insured in the sums insured for all farms—9.4%. Taking into account the average sums insured for crops in individual classes, the following regularity can be observed—with the increase in the level of land productivity, the average value of crop insurance increases (Table 6).

4. Discussion

Crop insurance is an important aspect in the functioning of farms, as it allows farmers to have a direct impact on the development and changes in the area of their activity, and is an important element of financial security in the event of unforeseen events. In this study, we analyzed the link between crop insurance and land productivity in the context of environmental changes. On the one hand, the level of land productivity among farmers is assessed using crop insurance, and on the other hand, the respondents assessed the relationship between the amount of insurance coverage and the agricultural practices used, which increase land productivity and at the same time exert pressure on the environment.

Research shows that crop insurance is the domain of large farms and those with a clear specialization in field crops. The vast majority of farmers using crop insurance are characterized by a high and very high level of productivity, and the average cost of crop insurance on these farms was twice as high compared with farms with low and medium productivity. Chakir and Hardelin [68] indicate that producers with higher expected

production are more willing to buy more insurance because the expected production value, and therefore also the possible loss, is higher. Farmers choose a higher level of protection with higher productivity. Farms benefiting from crop insurance with a very high level of productivity were characterized by a relatively high acreage of land for cultivation in the total agricultural area, higher consumption of pesticides and a higher degree of crop specialization. Crop insurance thus creates an incentive to activate more acres on arable land and to pursue monoculture. Risk subsidization, as indicated by Goodwin and Smith [42], may affect a change in the production model, i.e., the amount and allocation of acreage for individual crops. Crop insurance is a catalyst for farmers' decisions towards more risky crops and introducing additional, more risky land to production. As noted by Claassen et al. [32], these changes can mean the conversion of grassland to crop production and the increased use of fertilizers, pesticides and other chemicals in sensitive areas. Bergstrom et al. [69] indicated that converting marginal land from pasture to cultivation generally affects biodiversity and reduces its value as a wildlife habitat. Maisashvili et al. [70] suggested that land conversion to agricultural use often leads to vegetation-less areas that are particularly prone to rapid wind and water erosion. As land is transformed, farmers apply more pathogens and pollutant fertilizers, accelerating natural soil erosion and depletion. The study by Chang and Mishra [71] confirmed these assumptions and showed that the increase in insurance coverage increases the use of plant protection products in farms. According to Weber et al. [72], greater insurance coverage encourages farms to expand their arable land and use more fertilizers and chemicals per ha. Farmers buy more insurance and use more plant protection products because both reduce risk. This may indicate a possible complementarity between crop insurance and pesticides as a risk management tool. Chakir and Hardelin [68] also highlighted the occurrence of a size effect: it is widely recognized that pesticides not only reduce risk but also increase expected production, thereby increasing exposure to the second, multiplying risk. In this context, pesticides paradoxically constitute an additional risk factor, thus justifying the decision to purchase insurance [73]. Having insurance protection is also associated with greater specialization of farms [74], which is also a determining factor for productivity level. Production specialization is associated with limiting the use of natural diversity and will rather focus on the use of several varieties. Crop specialization and homogenization tend to eliminate species, disrupting soil structure and modifying nutrient and energy flows as well as biogeochemical cycles. Moreover, mass and selective harvesting practices also tend to reduce the diversity of the ecosystem, which will eventually destroy the mechanisms of its functioning and self-organization. Losing diversity not only affects the structure and functions of the ecosystem, but also increases the risk—the more homogeneous the system, the greater its susceptibility to pests, diseases, climate change, etc. [75].

Taking into account the use of specific practices affecting land productivity, i.e., increased area under cultivation, intensity of pesticide use or the level of cultivation differentiation, we note that there is a significant difference between farms from the group with the highest productivity and those from the group with the lowest productivity. In the case of farms with the lowest productivity, the intensity of pesticide use is three times lower than in the case of farms with the highest productivity. These farms were also characterized by a relatively greater diversity of crops than the others. These farms use crop insurance, but on a much smaller scale, as evidenced by a twice-lower average value of crop insurance compared to farms with higher productivity. The lower level of farm productivity may have an impact on farmers' decisions regarding the level of insurance coverage.

Glauber et al. [66] found that “subsidized crop insurance has been criticized for distorting resource allocation decisions, with impacts on the environmental sustainability of the sector. As a result, ... risk management tools aim to reduce risk, which often leads to increases in production” (p. 12). They enumerated some important distortions, including in crop mix, planted area, and input usage. These distortions may have significant environmental impacts, notably on water quality, soil erosion and greenhouse gas emissions. Li et al. [76] found that soil information could be incorporated into crop rating. First, it

provides a method to downscale the premium rating to the field level (or microlevel). That is, each individual piece of land can be precisely rated according to its risk characteristics. Sibiko and Quaim [77] examined determinants of the uptake weather index insurance scheme. They found that the aforesaid risk management instrument may raise productivity and intensity in the small farm sector. Purchase of insurance policies “significantly increases the use of chemical fertilizer and improved seed”. Embaye and Bertgold [78] studied the impact of crop insurance on the economic efficiency of farms in Kansas State between 1993 and 2015. They found that uptake of examined crop insurance affected catch-up and frontier shift positively and negatively respectively. Their result indicated that the effect of crop insurance on farm productivity (measured by the Almqvist index) is not statistically significant. They found that purchase of crop insurance is not optimal socially. Subsidized crop insurance may also discourage farmers and producers from adopting risk-reducing technologies. There is sound empirical evidence supporting this hypothesis [79–83]. In particular, according to Miao’s study [81], purchase of crop insurance policies may be treated as a tool for short-term risk mitigation. Biotechnology (inter alia, drought tolerant varieties) and agricultural engineering were regarded as important tools for the longer perspective.

5. Conclusions

This study revealed the links between the level of insurance coverage, land productivity and the environment on farms in Poland. The analysis showed that farms with a higher level of productivity achieved, inter alia, by the use of agricultural practices that have a negative impact on the environment, pay relatively higher premiums for crop insurance than farmers from farms with a lower level of productivity. Farms with a higher average value of crop insurance used most of the agricultural land for cultivation, which was slightly diversified, while using large amounts of pesticides. The level of productivity of these farms was also influenced by the level of earned income or the possibility of generating higher savings from operating activities. Additionally, it should be noted that on these farms the amount of subsidies for operating activities was the highest. This is of great importance for strengthening the position of farms and their ability to cope with unforeseen events. It may also indicate a possible complementarity between crop insurance and the use of specific productivity-enhancing practices, and the possibility of self-insurance as a risk management tool.

Our research shows that crop insurance in Poland is mainly used by farms with higher productivity. This creates moral hazards and riskier activities for these farmers. Therefore, the actions of the government authorities should focus on promoting risk management strategies that will provide farmers with an adequate level of protection, while caring for the environment. It becomes necessary to support technical progress on farms and changes in the behavioral attitudes of farmers that are focused on an intensive model of agriculture, mainly by increasing the expertise of farmers by allowing them greater access to financial support and more efficient and effective support from advisory institutions along with appropriate support for farmers to learn new production techniques and management of various crops, to diversify crops and to apply appropriate fertilization or plant protection products. Moreover, it is necessary to focus more public aid on financing specific investment projects that would improve the resilience of farms without their negative environmental impact. Moreover, more effective measures should be taken to increase the dissemination of crop insurance among farmers. Thanks to the organization of crop insurance, it will be possible to reduce costs and insurance in the long term. This may contribute to an increased use of crop insurance than before and the abandonment of some agricultural practices that exert pressure on the environment.

Our research results are consistent with previous empirical findings in developed countries. Glauber et al. [66] underlined that subsidized agricultural insurance (in particular, crop insurance) lead to several distortions (production choices and input use). The aforesaid distortions can cause some externalities affecting “the environment, climate,

nutrition and trade". Our research in the near future should be oriented in exploring the balance of the trade-off between short-term and long-term risk management tools, from the environmental and income-stabilization perspective [81].

Author Contributions: Conceptualization, A.K.-K. and A.S.-R.; methodology, A.S.-R.; software, A.S.-R.; validation, A.K.-K., A.S.-R., J.P.-T. and M.S.; formal analysis, A.K.-K., A.S.-R., J.P.-T. and M.S.; investigation, A.K.-K., A.S.-R., J.P.-T. and M.S.; resources, A.K.-K., A.S.-R., J.P.-T. and M.S.; data curation, A.K.-K., A.S.-R., J.P.-T. and M.S.; writing—original draft preparation, A.K.-K., A.S.-R., J.P.-T. and M.S.; writing—review and editing, A.K.-K., A.S.-R., J.P.-T. and M.S.; visualization, A.K.-K. and A.S.-R.; supervision, A.K.-K., A.S.-R., J.P.-T. and M.S.; project administration, A.K.-K., A.S.-R., J.P.-T. and M.S.; funding acquisition, M.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was financed under the project "Business insurance in holistic risk management in agriculture oriented towards sustainability, implementation of innovations and technologies and climate change mitigation" (acronym: UBROL) of the National Center for Research and Development (NCBR)—Strategic Programme GOSPOSTRATEG (Agreement No. Gospos- strateg1/390422/25/NCBR/2019 of 13/03/2019).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the authors. Data were obtained from Polish Farm Accountancy Data Network.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. Czakowski, D. Efficiency and productivity of farms in the basic markets of plant and production in Poland in the first decade after accession to the European Union. *Rocz. Stow. Ekon. Rol. Agrobiz.* **2017**, *19*, 34–40. [CrossRef]
2. Abdulai, A.; Abdulai, A. Examining the impact of conservation agriculture on environmental efficiency among maize farmers in Zambia. *Environ. Dev. Econ.* **2017**, *22*, 177–201. [CrossRef]
3. Fleckenstein, M.; Lythgoe, A.; Lu, J.; Thompson, N.; Doering, O.; Harden, S.; Getson, J.M.; Prokopy, L. Crop insurance: A barrier to conservation adoption? *J. Environ. Manag.* **2020**, *276*, 111223. [CrossRef] [PubMed]
4. Sporri, M.; Baráth, L.; Bokusheva, R.; Ferto, I. The Impact of Crop Insurance on the Economic Performance of Hungarian Cropping Farms. In Proceedings of the 123rd Seminar European Association of Agricultural Economists, Dublin, Ireland, 23–24 February 2012; p. 122525. [CrossRef]
5. Cornaggia, J. Does risk management matter? Evidence from the US agricultural industry. *J. Financ. Econ.* **2013**, *109*, 419–440. [CrossRef]
6. Tahamipour, M.; Zakre, M.R.; Abdollahi, M. Investigating the effect of insurance on the total productivity of agricultural production factors: Analysis based on index number approach. *Int. J. Econ. Politics* **2021**, *2*, 231–250. [CrossRef]
7. Coble, K.H.; Knight, T.O. Crop insurance as a tool for price and yield risk management. In *A Comprehensive Assessment of the Role of Risk in U.S. Agriculture*; Just, R.E., Pope, R.D., Eds.; Kluwer Academic Publisher: Boston, MA, USA, 2002; pp. 445–468.
8. Müller, B.; Johnson, L.; Kreuer, D. Maladaptive outcomes of climate insurance in agriculture. *Glob. Environ. Chang.* **2017**, *46*, 23–33. [CrossRef]
9. OECD. Towards Sustainable Land Use Aligning Biodiversity, Climate and Food Policies. 2020. Available online: <https://www.oecd.org/environment/towards-sustainable-land-use-3809b6a1-en.ht> (accessed on 2 August 2021).
10. Montanarella, L.; Scholes, R.; Brainich, A. (Eds.) *The IPBES Assessment Report on Land Degradation and Restoration*; Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services: Bonn, Germany, 2018.
11. INTOSAI. Working Group on Environmental Auditing (WGEA). Available online: <https://www.environmental-auditing.org/> (accessed on 2 August 2021).
12. Murphy, D.; DeVit, C.; Nolet, J. *Climate Change Mitigation through Land Use Measures in the Agriculture and Forestry Sectors*; IISD: Winnipeg, MB, Canada, 2009.
13. Federico, G. *Feeding the World: An Economic History of Agriculture, 1800–2000*; Princeton University Press: Princeton, NJ, USA, 2005.
14. Lobell, D.B.; Gourdji, S.M. The influence of climate change on global crop productivity. *Plant Physiol.* **2012**, *160*, 1686–1697. [CrossRef]
15. Kjellstrom, T.; Briggs, D.; Freyberg, C.; Lemke, B.; Otto, M.; Hyatt, O. Heat, Human Performance, and Occupational Health: A Key Issue for the Assessment of Global Climate Change Impacts. *Annu. Rev. Public Health* **2016**, *37*, 97–112. [CrossRef]

16. Ainsworth, E.A.; Yendrek, C.R.; Sitch, S.; Collins, W.J.; Emberson, L.D. The effects of tropospheric ozone on net primary productivity and implications for climate change. *Annu. Rev. Plant Biol.* **2012**, *63*, 637–661. [CrossRef] [PubMed]
17. Pacifici, M.; Foden, W.B.; Visconti, P.; Watson, J.E.M.; Butchart, S.H.M.; Kovacs, K.M.; Scheffers, B.R.; Hole, D.G.; Martin, T.G.; Akcakaya, H.R.; et al. Assessing species vulnerability to climate change. *Nat. Clim. Chang.* **2015**, *5*, 215–224. [CrossRef]
18. Goulson, D.; Nicholls, E.; Botías, C.; Rotheray, E.L. Bee declines driven by combined stress from parasites, pesticides, and loss of flowers. *Science* **2015**, *347*, 1255957. [CrossRef]
19. Flood, J. The importance of plan the path to food security. *Food Secur.* **2010**, *2*, 215–231. [CrossRef]
20. Neset, T.S.; Asplund, T.; Käyhkö, J.; Juhola, S. Making sense of maladaptation: Nordic agriculture stakeholders' perspectives. *Clim. Chang.* **2019**, *153*, 107–121. [CrossRef]
21. FAO. *Sustainable Agriculture for Biodiversity—Biodiversity for Sustainable Agriculture*; FAO: Rome, Italy, 2018. Available online: <http://www.fao.org/documents/card/en/c/85baf9c5-ea7f-4e25-812f-737755a8b320/> (accessed on 12 August 2021).
22. Tarnowska, A. Productivity of chosen production factors in agriculture in the European Union in the years 2005–2012. *Rocz. Nauk. Stow. Ekon. Rol. Agrobiz.* **2014**, *16*, 214–219.
23. Ozkan, B.; FigenCetlan, R.; Kizilay, H.A. Review of literature on productive efficiency in agricultural production. *J. Appl. Sci. Res.* **2009**, *5*, 769–801.
24. Bezat-Jarzębowska, A.; Rembisz, W. Productivity of land and its resources. *Probl. Rol. Świat.* **2016**, *16*, 9–18.
25. Pinnawala, S.; Herath, H. Social factors influencing agricultural productivity in the non-plantation agriculture in Sri Lanka: A farm centered analysis. In Proceedings of the 27th Annual Conference of the Organization of Professional Associations of Sri Lanka, Colombo, Sri Lanka, 27–28 September 2014. [CrossRef]
26. Sihem, E. Agricultural Insurance-Agricultural Productivity Nexus: Evidence from International Data. *J. Serv. Sci. Res.* **2017**, *9*, 147–178. [CrossRef]
27. Wąs, A.; Sulewski, P.; Kobus, P.; Majewski, E.; Pogodzińska, K.; Kulawik, J.; Soliwoda, M.; Kurdyś-Kujawska, A.; Osuch, D.; Kagan, A.; et al. Percepcja ryzyka przez rolników, jego źródeł i nastawień do niego oraz preferencji dotyczących instrumentów i strategii zarządzania nim—wyniki badań ankietowych. In *Identyfikacja Podstaw, Przemian i Problemów Ubezpieczeń Rolnych*; Soliwoda, M., Ed.; IAFE-NRI: Warsaw, Poland, 2020.
28. Pawłowska-Tyszkó, J.; Soliwoda, M. Agricultural insurance vs. economic and financial sustainability of farms. *Res. Pap. Wroc. Univ. Econ.* **2017**, *478*, 337–347. [CrossRef]
29. Kurdyś-Kujawska, A.; Sompolska-Rzechuła, A. The impact of economic insurance for the development of farms. *Wiad. Stat.* **2016**, *11*, 34–53. [CrossRef]
30. Hazell, P.B.R. The appropriate role of agricultural insurance in developing countries. *J. Int. Dev.* **1992**, *4*, 567–581. [CrossRef]
31. Pawłowska-Tyszkó, J. (Ed.) *Current Status and Prospects of Development of the Tax System and Insurance Scheme of the Polish Agriculture*; Monographs of Multiannual Programme, No 5.1; IAFE-NRI: Warsaw, Poland, 2015.
32. Claassen, R.; Langpap, C.; Wu, J. Impacts of federal crop insurance on land use and environmental quality. *Am. J. Agric. Econ.* **2017**, *99*, 592–613. [CrossRef]
33. Ren, C.; Liu, S.; VanGrinsven, H.; Reis, S.; Jin, S.; Liu, H.; Gu, B. The impact of farm size on agricultural sustainability. *J. Clean. Prod.* **2019**, *220*, 357–367. [CrossRef]
34. Wang, J.; Chen, K.Z.; DasGupta, S.; Huang, Z. Is small still beautiful? A comparative study of rice farm size and productivity in China and India. *China Agric. Econ. Rev.* **2015**, *7*, 484–509. [CrossRef]
35. Chuanmin, S.; Falla, J.S. Agro-industrialization: A comparative study of China and developed countries. *Outlook Agric.* **2016**, *35*, 177–182. [CrossRef]
36. European Commission. *Structure and Dynamics of EU Farms: Changes, Trends and Policy Relevance*; EU Agricultural Economics Brief No. 9; Directorate-General for Agriculture and Rural Development, European Commission: Brussels, Belgium, 2013. Available online: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/agri-economics-brief-09_en.pdf (accessed on 21 August 2021).
37. Rega, C.; Helming, J.; Paracchini, M.L. Environmentalism and localism in agricultural land-use policies can maintain food production while supporting biodiversity. Findings from simulations of contrasting scenarios in the EU. *Land Use Policy* **2019**, *87*, 103986. [CrossRef]
38. Zegar, J. *Współczesne Wyzwania Rolnictwa*; PWN: Warszawa, Poland, 2012.
39. Walters, C.; Shumway, C.; Chouinard, H.; Wandschneider, P. Crop Insurance, Land Allocation, and the Environment. *J. Agric. Resour. Econ.* **2012**, *37*, 301–320.
40. Goodwin, B.K.; Smith, V.H. An Ex Post Evaluation of the Conservation Reserve, Federal Crop Insurance, and Other Government Programs: Program Participation and Soil Erosion. *J. Agric. Resour. Econ.* **2003**, *28*, 201–216.
41. Weber, J.G.; Key, N.; O'Donoghue, E. Does Federal Crop Insurance Make Environmental Externalities from Agriculture Worse? *J. Assoc. Environ. Resour. Econ.* **2016**, *3*, 707–742. [CrossRef]
42. Goodwin, B.K.; Smith, V.H. What harm is done by subsidizing crop insurance? *Am. J. Agric. Econ.* **2013**, *95*, 489–497. [CrossRef]
43. Cai, H.; Chen, Y.; Fang, H.; Zhou, L.-A. The effect of microinsurance on economic activities: Evidence from a randomized field experiment. *Rev. Econ. Stat.* **2015**, *97*, 287–300. [CrossRef]

44. Sumner, D.A.; Zulauf, C. *Economic & Environmental Effects of Agricultural Insurance Programs*; The Council on Food, Agricultural, & Resource Economics, C-FARE Reports 156622; 2012. Available online: http://ageconsearch.umn.edu/bitstream/156622/2/Sumner-Zulauf_Final.pdf (accessed on 21 August 2021).
45. Chakir, R.; Hardelin, J. Crop Insurance and pesticide use in French agriculture: An empirical analysis. *Rev. Agric. Environ. Stud.* **2014**, *95*, 25–50. [\[CrossRef\]](#)
46. Rehman, A.; Chandio, A.A.; Hussain, I.; Luan, J. Fertilizer consumption, water availability and credit distribution: Major factors affecting agricultural productivity in Pakistan. *J. Saudi Soc. Agric. Sci.* **2019**, *18*, 269–274. [\[CrossRef\]](#)
47. Struik, P.C.; Kuyper, T.W. Sustainable intensification in agriculture: The richer shade of green. *Agron. Sustain. Dev.* **2017**, *37*, 39. [\[CrossRef\]](#)
48. Lin, B.B.; Perfecto, I.; Vandermeer, J. Synergies between Agricultural Intensification and Climate Change Could Create Surprising Vulnerabilities for Crops. *BioScience* **2008**, *58*, 847–854. [\[CrossRef\]](#)
49. Devarinti, S.R. Natural Farming: Eco-Friendly and Sustainable? *Agrotechnology* **2016**, *5*, 147. [\[CrossRef\]](#)
50. Diaz, S.; Settele, J.; Brondizio, E.; Ngo, H.; Guèze, M.; Agard, J.; Butchart, S. *Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services: Paris, France, 2019. Available online: <https://bit.ly/37HN35q> (accessed on 21 August 2021).
51. IPCC. *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems—Summary for Policy Makers*; IPCC: Geneva, Switzerland, 2019. Available online: <https://bit.ly/2U1gzza> (accessed on 12 August 2021).
52. Möhring, N.; Dalhaus, T.; Enjolras, G.; Finger, R. Crop insurance and pesticide use in European agriculture. *Agric. Syst.* **2020**, *184*, 102902. [\[CrossRef\]](#)
53. Deryugina, T.; Konar, M. Impacts of crop insurance on water withdrawals for irrigation. *Adv. Water Resour.* **2017**, *110*, 437–444. [\[CrossRef\]](#)
54. Hwang, C.L.; Yoon, K. *Multiple Attribute Decision Making. Methods and Applications*; Springer: Berlin, Germany, 1981.
55. Yoon, K. Are conciliation among discrete compromise situations. *J. Oper. Res. Soc.* **1987**, *38*, 277–286. [\[CrossRef\]](#)
56. Hwang, C.L.; Lai, Y.J.; Liu, T.Y. A new approach for multiple objective decision making. *Comput. Oper. Res.* **1993**, *20*, 889–899. [\[CrossRef\]](#)
57. Hellwig, Z. Zastosowanie metody taksonomicznej do typologicznego podziału krajów ze względu na poziom ich rozwoju oraz zasoby i strukturę wykwalifikowanych kadr. *Prz. Stat.* **1968**, *4*, 307–327.
58. Łuczak, A.; Kalinowski, S. Assessing the level of the material deprivation of European Union countries. *PLoS ONE* **2020**, *15*, e0238376. [\[CrossRef\]](#) [\[PubMed\]](#)
59. Bulgurcu, B.K. Application of TOPSIS Technique for Financial Performance Evaluation of Technology Firms in Istanbul Stock Exchange Market. *Procedia-Soc. Behav. Sci.* **2015**, *62*, 1033–1040. [\[CrossRef\]](#)
60. Bhutia, P.W.; Phipon, R. Application of ahp and topsis method for supplier selection problem. *IOSRJ. Eng. (IOSRJEN)* **2012**, *2*, 43–50. [\[CrossRef\]](#)
61. Nowak, A.; Krukowski, A.; Różańska-Boczula, M. Assessment of Sustainability in Agriculture of the European Union Countries. *Agronomy* **2019**, *9*, 890. [\[CrossRef\]](#)
62. Baral, A.; Behera, S. Application of Fuzzy TOPSIS to Agricultural Farm for Optimum Allocation of Different Crops. *Int. J. Sci. Res.* **2017**, *6*, 2059–2064.
63. Džunić, M.; Stanković, J.; Janković-Milić, V. Multi-Criteria Approach in Evaluating Contribution of Social Entrepreneurship to The Employment of Socially-Excluded Groups. *Technol. Econ. Dev. Econ.* **2018**, *24*, 1885–1908. [\[CrossRef\]](#)
64. Wysocki, F. *Metody Taksonomiczne w Rozpoznawaniu Typów Ekonomicznych Rolnictwa i Obszarów Wiejskich*; Poznan University of Life Sciences: Poznan, Poland, 2010.
65. Vafaei, N.; Ribeiro, R.A.; Camarinha-Matos, L.M. Data normalisation techniques in decision making: Case study with TOPSIS method. *Int. J. Inf. Decis. Sci.* **2018**, *10*, 19–38. [\[CrossRef\]](#)
66. Glauber, J.; Baldwin, K.; Antón, J.; Ziebinska, U. *Design Principles for Agricultural Risk Management Policies*; OECD Food, Agriculture and Fisheries Papers, No. 157; OECD Publishing: Paris, France, 2021. [\[CrossRef\]](#)
67. Kukuła, K. *Metoda Unitaryzacji Zerowanej*; PWN: Warszawa, Poland, 2000.
68. Chakir, R.; Hardelin, J. *Crop Insurance and Pesticides in French Agriculture: An Empirical Analysis of Multiple Risks Management*; Working Papershal-00753733; HAL, 2010. Available online: <https://hal.archives-ouvertes.fr/hal-00753733> (accessed on 21 August 2021).
69. Bergstrom, J.C.; Goetze, S.J.; Shortle, J.S. *Land Use Problems and Conflicts. Causes, Consequences and Solutions*, 1st ed.; Routledge: London, UK, 2004.
70. Maisashvili, A.; Bryant, H.L.; Jones, J.P.H. Implications of alternative crop insurance subsidies. *J. Agric. Appl. Econ.* **2020**, *52*, 240–263. [\[CrossRef\]](#)
71. Chang, H.; Mishra, A. Chemical usage in production agriculture: Do crop insurance and off-farm work play a part? *J. Environ. Manag.* **2012**, *105*, 76–82. [\[CrossRef\]](#) [\[PubMed\]](#)
72. Weber, J.G.; Key, N.; O'Donoghue, E.J. Does Federal Crop Insurance Encourage Farm Specialization and Fertilizer and Chemical Use? Presented at the 2015 AAEA and WAEA Annual Meetings, San Francisco, CA, USA, 26–28 July 2015.

73. Horowitz, J.K.; Lichtenberg, E. Insurance, moral hazard, and chemical use in agriculture. *Am. J. Agric. Econ.* **1993**, *75*, 926–935. [[CrossRef](#)]
74. O'Donoghue, E.J.; Roberts, M.; Key, N. Did the Federal Crop Insurance Reform Act Alter Farm Enterprise Diversification. *J. Agric. Econ.* **2009**, *60*, 80–104. [[CrossRef](#)]
75. Skendžić, S.; Zovko, M.; Živković, I.P.; Lešić, V.; Lemić, D. The Impact of Climate Change on Agricultural Insect Pests. *Insects* **2021**, *12*, 440. [[CrossRef](#)]
76. Li, T.; Wang, H.; Zhou, Z.; Chen, X.; Zhou, J. A new grading system for plant-available potassium using exhaustive cropping techniques combined with chemical analyses of soils. *Sci. Rep.* **2016**, *6*, 37327. [[CrossRef](#)] [[PubMed](#)]
77. Sibiko, K.W.; Qaim, M. *Weather Index Insurance, Agricultural Input Use, and Crop Productivity in Kenya*; Global Food Discussion Papers, No. 94; Georg-August-Universität Göttingen, Research Trainin Group (RTG) 1666—Global Food: Göttingen, Germany, 2017.
78. Embaye, W.T.; Bergtold, J.S. Effect of Crop Insurance Subsidy on Total Farm Productivity of Kansas Farms. In Proceedings of the US Annual Meeting, Chicago, IL, USA, 30 July–1 August 2017.
79. Woodard, J.D.; Pavlista, A.D.; Schnitkey, G.D.; Burgner, P.; Ward, K.A. Government Insurance Program Design, Incentive Effects, and Technology Adoption: The Case of Skip-Row Crop Insurance. *Am. J. Agric. Econ.* **2012**, *94*, 823–837. [[CrossRef](#)]
80. Miao, R. Climate, Insurance and Innovation: The Case of Drought and Innovations in Drought-Tolerant Traits in US Agriculture. *Eur. Rev. Agric. Econ.* **2020**, *47*, 1826–1860. [[CrossRef](#)]
81. Miao, R. Trade off between Short-Term and Long-Term Risk Management Tools: New Study Shows That Crop Insurance May Hinder Agricultural Innovations in Drought-Tolerant Technologies, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign. 2020. Available online: <https://farmdocdaily.illinois.edu/2020/06/tradeoff-between-short-term-and-long-term-risk-management-tools.html> (accessed on 20 August 2021).
82. Kumar, A.; Saroj, S.; Mishra, A.K. *Crop Insurance and Crop Productivity: Evidence from Rice Farmers in Eastern India*; IFPRI Discussion Paper 1996; International Food Policy Research Institute: Washington, DC, USA, 2021. [[CrossRef](#)]
83. Shi, J.; Wu, J.; Olen, B. Assessing effects of federal crop insurance supply on acreage and yield of specialty crops. *Can. J. Agric. Econ.* **2019**, *68*, 65–82. [[CrossRef](#)]