

Article

Impact of Agricultural Policies on the Sustainable Greenhouse Development in Biskra Region (Algeria)

Toufik Aidat ¹, Salah Eddine Benziouche ¹, Leonardo Cei ^{2,*} , Elisa Giampietri ^{2,*}  and Antonio Berti ³

¹ Laboratory of Ecosystem Diversity and Dynamics of Agricultural Production Systems in Arid Zones (DEDSPAZA), Department of Agronomic Sciences, Faculty of Exact Sciences and Natural Sciences and Life, University Mohamed Khider of Biskra, Biskra 07000, Algeria; toufik.aidat@univ-biskra.dz (T.A.); s.benziouche@univ-biskra.dz (S.E.B.)

² Department of Land, Environment, Agriculture and Forestry (TESAF), University of Padova, 35020 Padova, Italy

³ Department of Agronomy, Food, Natural Resources, Animals and Environment (DAFNAE), University of Padova, 35020 Padova, Italy; antonio.berti@unipd.it

* Correspondence: leonardo.cei@unipd.it (L.C.); elisa.giampietri@unipd.it (E.G.)

Abstract: Since its appearance in Algerian agriculture, the greenhouse production system has turned the agricultural sector upside down, bringing great advantages for production in terms of quality and quantity, creating a very important socio-economic dynamic, especially in the Saharan region. This paper makes a new contribution by providing information on the impact of agricultural policies on greenhouse development in Biskra (southeastern city in Algeria). This study aims to understand the type of farms/farmers most specialized in greenhouses as well as the relationship between the use of these land acquisition and financing policies (PNDA) and their degree of specialization in greenhouses. A field survey was held from February to April 2021 in the M'ziraa region (a municipality of Biskra City), completing 97 questionnaires. Collected data were analysed by Ordinary Least Squares (OLS) regression and Truncated regression. The results show that farmers who used PNDA to acquire the land and for greenhouse investments and those with a lower education level are less likely to specialize in greenhouse production. Similarly, the effect of farm size is negative on the specialization in greenhouse production. Conversely, we found that farmers who do not directly manage the farm and those who have a longer experience with greenhouse production invest a higher share of their land in greenhouses.

Keywords: agricultural policies; greenhouse production; Algeria; Saharan agriculture



Citation: Aidat, T.; Benziouche, S.E.; Cei, L.; Giampietri, E.; Berti, A. Impact of Agricultural Policies on the Sustainable Greenhouse Development in Biskra Region (Algeria). *Sustainability* **2023**, *15*, 14396. <https://doi.org/10.3390/su151914396>

Academic Editor: Marc A. Rosen

Received: 3 July 2023

Revised: 25 September 2023

Accepted: 28 September 2023

Published: 30 September 2023



Copyright: © 2023 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

Modern agricultural techniques aimed at increasing food production often have a negative impact on other ecosystem services, such as water conservation and soil fertility [1]. However, sustainable intensification of agriculture can help solve these problems, addressing the food security challenge by producing more food using less land and reducing overall negative environmental impacts [2]. One promising option for agricultural intensification is the cultivation of vegetables in a greenhouse. Greenhouses provide a controlled environment for plant growth, allowing for year-round production and the ability to grow crops in regions where they might not otherwise be able to grow. According to a recent report by the Food and Agriculture Organization (FAO) of the United Nations [3], the total area of greenhouse crops worldwide was estimated at 4.9 million hectares in 2019, with most greenhouse crops grown in Asia (59%), followed by Europe (21%) and North America (16%). The most grown greenhouse crops globally include vegetables such as tomatoes, cucumbers, and peppers, as well as ornamental plants like flowers.

Algerian agriculture has undergone considerable economic and social changes over the past two decades as a consequence of specific State efforts aiming at better organizing

the agri-food chains and the market and encouraging agricultural investments and exports through some agricultural policy reforms, as the “National Agricultural Development Plan” (PNDA—Plan National de Développement Agricole), launched in the 2000s. These State actions brought new prospects for agricultural development, especially in the Saharan regions, through the transition from the old oasis production system, based on date palms and livestock farming, to a new diversified system comprising greenhouse crops, underlying crops, and livestock farming [4–6]. It was under this policy program that greenhouse crops began to flourish in the wilaya (province) of Biskra. The PNDA has several objectives that refer to the different dimensions of sustainability: i.e., ensuring food security in the country, making rational and sustainable use of natural resources (i.e., water and land) by subsidising farmers with irrigation systems (drip irrigation), and the construction of boreholes and water storage basins to reduce the environmental impact of a greenhouse. This promotes job creation and local economic development and improves farmers’ living conditions and profitability.

Previously, greenhouse production in Algeria was faced with several challenges, including the high cost of building and equipping greenhouses, lack of production factors (land and water), limited availability of qualified personnel in greenhouse vegetable production, and inadequate marketing infrastructure. In this case, the Algerian government has implemented policies to support the development of greenhouse crop production, including subsidies for greenhouse construction and equipment and facilitation of access to land development. Most greenhouse production in Algeria is concentrated in the south of the country (e.g., Biskra region), where the climate is more favourable for year-round production. Moreover, these Saharan regions have a huge territory that covers about 75% of the national scale area [7]. They also have significant water resources, mainly consisting of non-renewable groundwater reservoirs, which enable them to become excellent agricultural sites. Since the promulgation of the “Access to Agricultural Land Development” (APFA) law in 1983, the Saharan regions, including Ziban (Biskra region), experienced a certain agricultural dynamism by attracting new investors from other cities of the country [8–10].

This article contributes to the knowledge of the greenhouses’ development in the Biskra region. It sheds empirical light on agricultural development policies during the last thirty years, which were marked by a clear orientation to encourage the development of agriculture in the southern regions, where date palms used to be the only source of income for farmers. These policies are considered a very important choice, allowing the lifting of the constraints of access to production resources (land). However, little research has been conducted on this topic to understand the specific factors impacting the adoption and success of greenhouse cultivation in the Biskra region. This study aims to understand the relationship between the degree of specialization of farms in greenhouse production and the use of PNDA to acquire land.

2. Background on the Policy Support to Agricultural Production in Algeria

The agricultural development of the arid regions in Algeria started in the early 1980s under Law No. 83-18, which encouraged access to agricultural land [11–13]. Its main objective was to increase agricultural production by mobilizing new natural resources (land and water) not exploited yet by the sector. The land was the private domain of the State, especially that located in the arid zones of the country (i.e., steppes and Sahara). These lands were allocated to Algerian farmers, i.e., holders of agricultural projects, according to two possible regulatory channels. The first concerned the transfer of the ownership right subject to the effective land development (see Law no. 83-18 granting access to land development), while the other concerned the transfer of a 40-year concession right (see Law no. 08-16 on agricultural policy) [14]. In addition to these legal and regulatory instruments, the State mobilized large financial resources to support development operations on the ground [11]. Thus, it promoted numerous development programs (i.e., land acquisition, agricultural electrification, the realization of collective drilling, and opening of agricultural tracks) along the perimeter of several cities in the country and, at certain periods, it funded

individual farm investments and facilitated the access to credit for private farmers. So far, only a relatively small proportion of the distributed area has been developed. Indeed, for the areas allocated under APFA, the total balance sheet established in 2013 by the National Office of Agricultural Lands (ONTA) shows that 17.7% of the 810 thousand allocated ha were developed [15].

The development of greenhouse vegetable production in the Biskra region began in the 1990s in the wake of the agricultural land development policy, but the real boom dates to the 2000s, thanks to the multiple public support for farm investments provided under the PNDA. Under this program, the State also funded drilling and equipment for drip irrigation [15,16]. This additional support played an important role since vegetable farmers are mostly small producers (with, on average, 0.5 ha), often specialized in one or two crops [12], and direct bank financing for greenhouses is marginal. In this respect, in 2009, total operating loans granted to the greenhouse sector amounted to just USD 42,000 nationally. In addition, investment loans for greenhouses were considerably reduced, from USD 1.9 million in 2009 to USD 500 thousand in 2012 and USD 74 thousand in 2020 under the new El-Tahadi program [17]. Today, according to [18], the emergence of this new production zone as an agricultural hub is no accident. In fact, it is the result of a process of transformation of production methods (e.g., introduction of new crops, adoption of new technologies) in coordination with the new development of agricultural land and the new funding opportunities offered by the PNDA. The launch of the PNDA has generated renewed interest and activity in these regions, which has not only helped to improve food security in these areas and in the country but also to create jobs and improve farmers' living standards [19]. Moreover, in areas where the development has been successful, the results have been quite impressive: veritable agricultural poles have emerged, bringing about a change in the geography of agricultural production in Algeria. The Biskra region is a good example of the success of greenhouse farming in southern Algeria, with its 37% share of national vegetable production [18]. As reported in Figure 1, in the last 20 years, both greenhouse area and greenhouse production experienced a continuous increase, which has been particularly sharp after 2010.

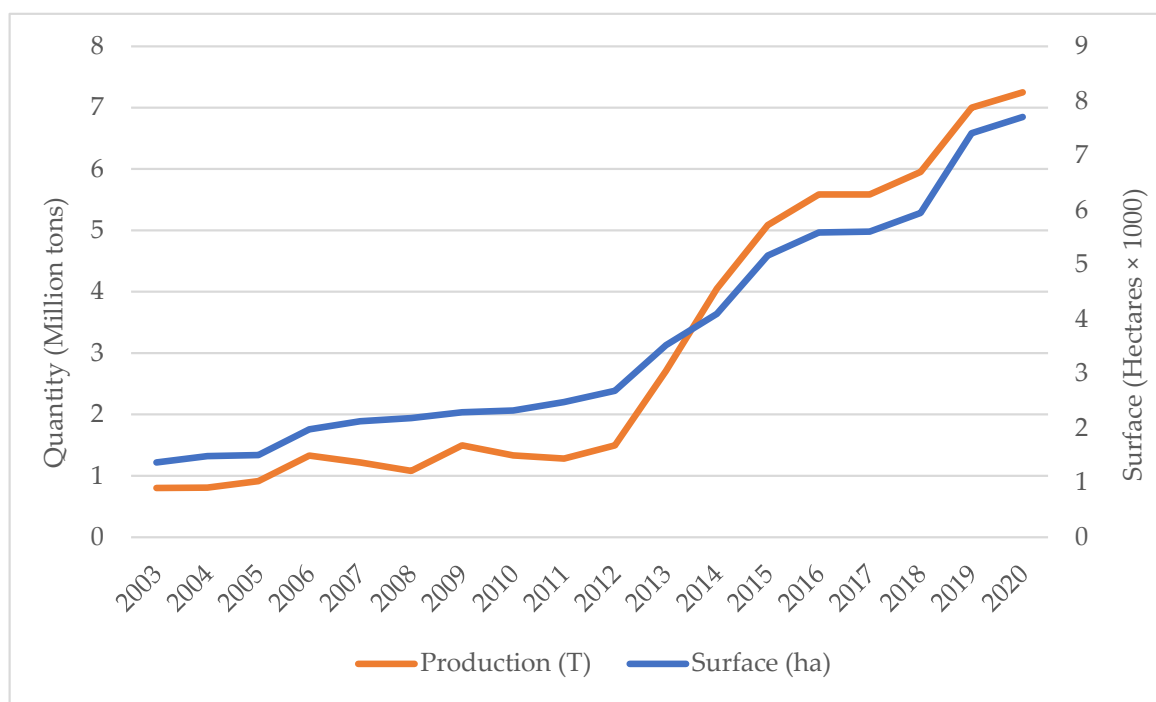


Figure 1. Greenhouse surface and production in Biskra region, 2000–2020.

3. Study Area

Biskra region is located in the northeast of the Algerian Sahara, covering an area of 3 thousand square kilometers. The study area is characterized by a hot desert climate according to Koppen's classification; the mean annual rainfall rarely exceeds 150 mm, the mean annual evaporation is 2.5 thousand mm, and the mean temperature ranges from 11 °C (coldest month: January) to 35 °C (hottest month: July) [20]. The study area is generally flat, with undulating ridges and mountain ranges (the lowest altitude in the Oumache area is 43 m, and the highest altitude in the western part of the area is 283 m). Geologically, almost the entire study area belongs to the recent Quaternary, which is a favorable situation for groundwater recharge and occurrence [21,22]. Like all soils in the world's arid regions, the soils of Algeria's Saharan zone contain relatively large quantities of soluble salts, whose accumulation is due to the scarcity of rainfall that slows down the leaching of these salts [23]. This region has favorable conditions to produce greenhouse crops, including abundant sunshine and access to water resources through irrigation systems. Greenhouses in this region represent an important source of employment and income for the rural population. Accordingly, they offer small farmers the opportunity to increase their yields and incomes and create job opportunities [24,25]. Thirty years ago, the Biskra region was known for three main agricultural activities, namely date palm, sheep livestock, and cereals production, while in recent years, it has undergone a change in the production system mainly due to the development of greenhouse production. This sector, like a date palm, experienced very significant growth in the last two decades, especially in some regions such as El-Ghrous, M'ziraa, Doucen, and Ain Naga [26]. The main crops grown in these regions include tomatoes, hot and sweet peppers, cucumbers, and melons [9]. The introduction of greenhouses in the region of Biskra has breathed a real socio-economic dynamic through the creation of wealth. Experts in the agricultural sector explain this dynamic by the concurrence of several factors, such as the increase in public support to agriculture through different rural development programs (e.g., PNDA and APFA), the use of innovations in production technologies and their improvement, the new expertise acquired by young investors, the greenhouse surface multiplication and the installation of new types of greenhouses such as the Multi-Greenhouse and the Canarian Greenhouse [27]. Greenhouses are a major source of income for the region's populations, with growers, traders, input suppliers, temporary farm employees, collectors, seed merchants, and other suppliers providing growers with the necessary equipment. The large amount of commercial activity generated in these regions at the harvest time in the six wholesale markets also benefits the people living in these areas. Overall, the socio-economic dynamism of the production areas is very strong. Indeed, there has been a major improvement in the income and, consequently, the standard of living of producers and households. This has made a major contribution to reducing poverty in the communes where the vegetable is grown and decreasing the unemployment rate from 23.8% in 1992 to less than 10% in recent years. Agriculture is making a major contribution to this decline in the region [27].

The growth of greenhouse in Biskra is partly linked to fruit and vegetable wholesale markets, which include three wholesale markets (i.e., M'ziraa, Ain Naga, and El-ghrous), most of whose production is destined for the eastern and central regions of the country. A large proportion of off-season market garden produce passes through these markets, which are frequented by traders from all the country's urban centers. They are also characterized by their system of direct sales from producers to traders. This makes them a real hub of information, both between local producers and between producers and traders. Producers receive information about consumer preferences and periods of imbalance between supply and demand. A study on the structure of the El-Ghrous market, how it operates, and its role in price formation and producer remuneration was carried out by [28].

The agricultural area in the Biskra region is estimated at 1.6 million hectares, including grazing land and land used for agriculture. The Utilized Agricultural Area (UAA) for farming is 185 thousand ha. The area irrigated in this region is 111 thousand hectares, of

which 24 thousand hectares are cultivated with winter cereals. Palm-growing occupies an area of 42 thousand hectares, i.e., approximately 4.5 million palm trees. Greenhouses cover an area of around 25 thousand ha, while forage crops occupy an area of only 7 thousand ha. The area under trees does not exceed 5 thousand ha, and the area under olive trees is 4.5 thousand ha [29].

To date, the Biskra region has become a pole of greenhouse crop production, which has experienced a considerable evolution in the last twenty years. According to the statistics provided by the Agricultural Services Direction of Biskra [29], in 2000, the agricultural area occupied by greenhouses was about 1 thousand ha, with most of them devoted to the production of tomatoes (689 ha), hot peppers (438 ha), and sweet peppers (202 ha). In terms of production, 77 thousand tons were harvested in 2000, including 51 thousand tons of tomatoes, 17 thousand tons of hot pepper, and 9 thousand tons of sweet pepper. In 2020, the total greenhouses' area was estimated at 7 thousand ha, with the majority devoted to tomatoes (2 thousand ha), hot peppers (1 thousand ha), and sweet peppers (778 ha). Also, the total production under greenhouse amounts to 725 thousand tons, and among the major crops, we find 316 thousand tons for tomatoes, 99 thousand tons for hot peppers, and 62 thousand tons for sweet peppers. As further evidence highlighting the agricultural importance attained by the Biskra region, the regional planted area with greenhouses represents more than 49% of the total national greenhouse planted area. Moreover, the production represents about 60% of the total Algerian greenhouse production. The recent achievements in greenhouse production at the national level, and especially in the Biskra region, are mainly due to several factors such as favourable climatic conditions, availability of water resources, and the launch of the PNDA in 2000 [9]. In addition, a role is played by the benefit generated by greenhouses compared to date palms since, according to [30], the income from a greenhouse is equivalent to that of 20 Deglet-nour palms. Despite all these advantages, the phytosanitary situation on greenhouse farms in Biskra is very worrying due to the microclimate that favors the development of pests and diseases. These are causing major losses and a loss of earnings in terms of both quantity and quality. This is due to the very traditional way in which crops are grown, and phytosanitary treatments have been abandoned. The main diseases and pests that attack crops in Biskra, according to producers, are (i) diseases caused by insects (white-fly, mites, aphids, trips, defoliating noctuid moths), (ii) fungal diseases: root diseases (fusariosis, pythium, verticillium), mildew, oidium [31]. In this region, there is little rational management of agrochemicals, and farming is based on the preventive use of pesticides. The growing quantity of chemical inputs is the result of their great potential to improve crop productivity to increase crop yields and farmers' incomes through the systemic elimination of all harmful pests and diseases. However, these doses used can lead to undesirable effects such as an increase in the resistance of harmful vectors, leading to the appearance of a new generation that is more tolerant to insecticides; a risk of intoxicated farmers; and contamination of water and air [32–34]. The risk of inappropriate use of pesticides can be exacerbated by a lack of training and technical advice. This leads to risky practices and also hampers the development of healthy and sustainable agriculture [35].

4. Materials and Methods

The study survey was conducted from February to April 2021 on a sample of greenhouse farmers (N = 97) in the Biskra region in Algeria, particularly in the leading municipality for greenhouse crop production, i.e., M'ziraa (Figure 2).

Face-to-face interviews with a questionnaire were carried out among producers of tomatoes, eggplants, hot peppers, and sweet peppers. Those farmers represent more than 40% of the total regional farmers in the case study area. A pre-investigation was carried out from February to March 2019 to test the feasibility of the study questionnaire on a sample of 45 farmers.

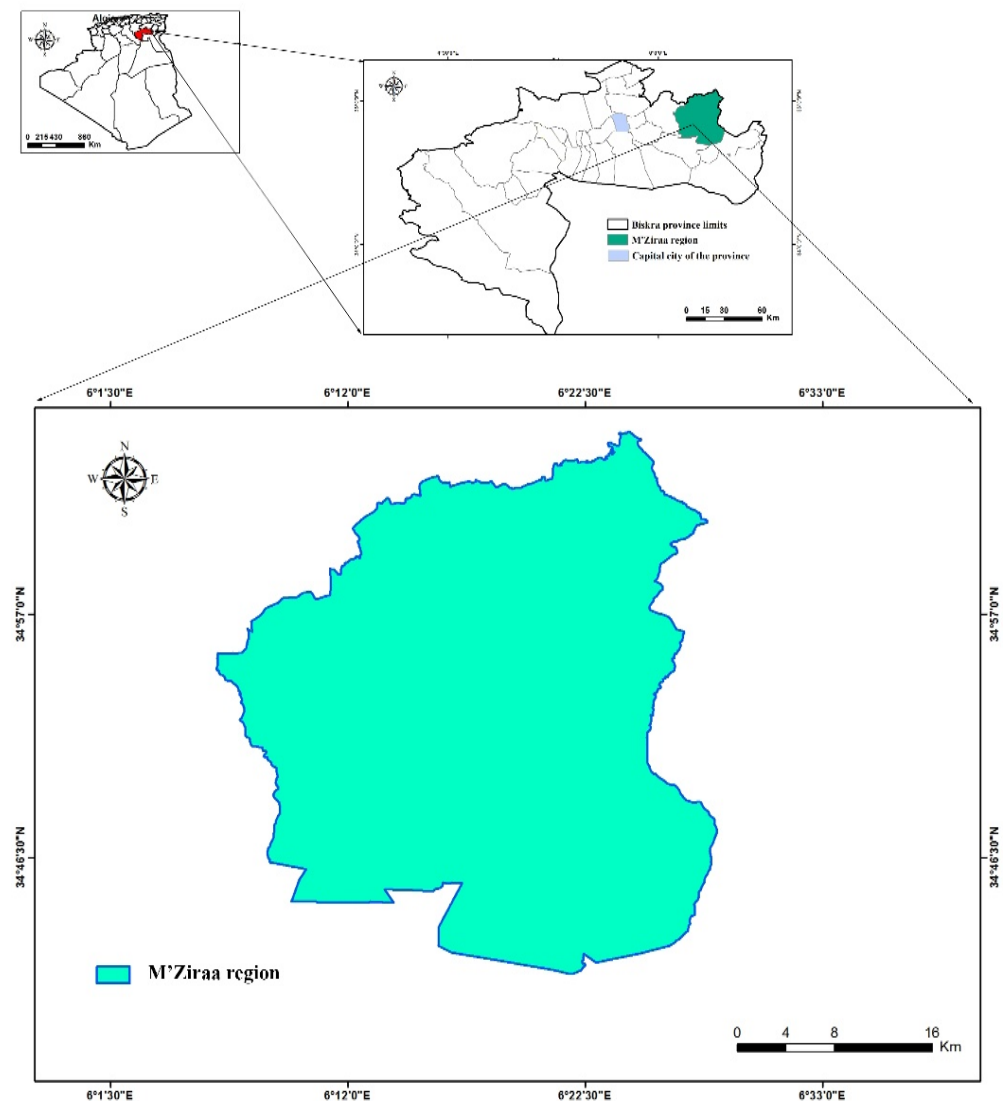


Figure 2. Study area location Biskra region (M'ziraa).

The questionnaire was structured as follows: first, we collected data on household characteristics (i.e., age, level of education, experience in greenhouse cultivation and training). Then, in a second section, we included questions about the mode of acquisition of agricultural land, the tenure of land (i.e., direct or indirect), and farms' characteristics, such as the total farm size and the greenhouses area, both in hectares. As for the mode of agricultural land acquisition, it is aimed at understanding the different mechanisms by which farmers and landowners have access to the agricultural land and can implement their greenhouse investments, namely purchase, rent, and use of public support provided by PNDA. The farm management mode refers to the way in which the surveyed farms are managed, i.e., directly or indirectly by the farm owner.

The collected variables were used to study the relationship between several farm characteristics and the degree of farm specialization in greenhouse production. Among these characteristics, we included farmers' use of PNDA for land acquisition and greenhouse investments. This responds to the overarching aim of our study, i.e., to assess the impact of agricultural policies on the promotion of greenhouse crops in the study region. The farm specialization in greenhouse production was measured by a variable indicating the proportion of land used in each farm for greenhouse crops in relation to the total farm area. This variable, named greenhouse share, was obtained by dividing the farm area allocated to greenhouse production and the total farm area.

Table 1 reports the summary statistics of the considered variables for the sample used for the statistical elaborations. The average age of the farmers surveyed is 42. Moreover, 42% of the farmers have a middle school level, while 84.5% of them have no formal agricultural training. In terms of access to land, it is shown that 65% of the sample used the PNDA to acquire land and to implement greenhouse production at their farm. Therefore, we can observe that the greenhouse share for the respondent farmers amounts to 0.2 on average. Furthermore, for the tenure of land, 70% of landowners use the indirect mode to manage their farms, while only 30% manage their farms directly.

Table 1. Sample descriptive statistics (N = 97).

Variable	Description	Mean	Median	Std.Dev.	Inter-Quartile Range	Min	Max	Share of Observations (%)
Age	(years) (X_3)	41.63	41	9.62	14	21	66	-
Educational level	1 = Illiterate/ Primary (X_4)							14.4
	2 = Middle school							42.3
	3 = Secondary/ high school (X_5)							24.7
	4 = University (X_6)							18.6
Acquisition of land	1 = Purchase (X_1)							9.3
	2 = PNDA (X_2)							64.9
	3 = Rent							25.8
Tenure of land	1 = Direct							29.9
	2 = Indirect (X_8)							70.1
Total Area	(hectares) (X_9)	13.24	11.00	9.81	8.00	1.00	58.00	
Greenhouse area	(hectares)	2.37	2.00	2.01	1.50	0.30	12.50	
Greenhouse share	(%) (Y)	0.23	0.17	0.19	0.18	0.03	1.00	
Training	1 = yes (X_7)							15.5
	0 = no							84.5
Experience	(years) (X_{10})	17.72	19	8.27	13	4	36	
Phytosanitary problems	1 = yes							100
Chemical plant protection	1 = yes							100
Water source	Borehole							100

To identify the relationship between the different farm characteristics and greenhouse specialization, we adopted a regression approach. Specifically, the log of the greenhouse share was used as the dependent variable in an OLS framework. Since the greenhouse share is a proportion (i.e., taking values in the $[0; 1]$ set), its logarithm potentially displays a right truncated distribution (taking values in the $(-\infty; 0]$ set). However, a visual analysis of this distribution, as well as the Shapiro–Wilk test, reveals that the normality assumption cannot be rejected. Nevertheless, to check the robustness of the results, we also performed a truncated regression. In addition, as a further robustness check, we implemented a beta-regression on the original greenhouse share variable (i.e., without the log transformation). The beta-regression is, in fact, specifically devised for proportion-dependent variables. Overall, the three models provide similar results. All the data elaborations were performed in Stata 17 and SPSS 26.

5. Results

Table 2 presents the results from the OLS and the truncated regression on the logarithm of the farm greenhouse share in the Biskra region. For convenience, we decided to omit the results of the beta-regression, considering that they are similar and that this regression was performed only to check the robustness of the original model. They are available, however, from the authors upon request. The R-square and the pseudo-R-square of the OLS and truncated regressions are 0.33 (adjusted OLS R-square: 0.25). These values are comparable to other studies investigating the impact of farm characteristics on technology adoption [36,37]. The analysis of residuals confirmed the goodness of the model (normality, absence of non-linear relationships, absence of influential observations), while heteroskedasticity was not detected (Breusch–Pagan test p -value = 0.959).

Table 2. Results from the ordinary least squares and truncated regressions (sample size = 97).

Variable	OLS			Truncated Regression (TR)		
	β	Std.err.	p -Value	β	Std.err.	p -Value
Purchase (X_1)	−0.248	0.251	0.325	−0.262	0.246	0.287
PNDA (X_2)	−0.420	0.158	0.009	−0.436	0.155	0.005
Age (X_3)	−0.010	0.0088	0.260	−0.010	0.008	0.229
Education_illi_prim (X_4)	−0.717	0.209	0.001	−0.732	0.201	0.000
Education_second (X_5)	−0.005	0.162	0.976	−0.003	0.157	0.987
Education_univ (X_6)	0.033	0.182	0.856	0.032	0.176	0.854
Training (X_7)	0.254	0.184	0.171	0.259	0.177	0.143
Tenure (X_8)	0.305	0.147	0.041	0.312	0.142	0.028
Total area (X_9)	−0.026	0.007	0.000	−0.027	0.007	0.000
Experience (X_{10})	0.028	0.0097	0.004	0.029	0.009	0.002
_cons	−2.096	0.4847	0.000	−2.096	0.466	0.000
Prob > F		0.000			0.000	
R ²		0.332			0.332	
Adjusted R ²		0.254			–	
Log-likelihood		–			−84.99	

Looking at the estimated parameters, the first evidence is the similarity between standard OLS and the truncated regression estimates, which supports the robustness of the findings. The coefficients associated with PNDA suggest that farmers who made use of PNDA to acquire the land and for greenhouse investments are more likely to be less specialized in greenhouse production. Indeed, we found that, on average, these farmers have 42–44% less greenhouse share in their farms compared to those who rented the land. Moreover, we find a significant effect of education since an F test for joint significance of the education variables provided a p -value of 0.005. Specifically, farmers with a lower education level are less likely to specialize in greenhouse production ($\beta_{OLS} = -0.72$; $\beta_{TR} = -0.73$), while no difference is observed between farmers with middle, secondary, and university levels of education. Furthermore, farmers who do not directly manage the farm (i.e., those who employ external workers) are more likely to have a higher share of greenhouse ($\beta_{OLS} = 0.31$; $\beta_{TR} = 0.31$). Similarly, we found a positive effect of having a longer experience with greenhouse production: farmers being involved in greenhouse production for a longer time invest a higher share of their land in greenhouses. Finally, the effect of farm size is negative on the specialization in greenhouse production, namely decreasing the greenhouse share by 2.6–2.7% on average for each additional hectare. Opposite this, we found no significant effect for age and training. In addition, the greenhouse specialization does not vary between farmers purchasing or renting the land.

Over the last two decades, Algeria has experienced remarkable agricultural development driven by prosperity in greenhouses due to favourable climatic conditions and government policies, which are the focus of this paper. Obviously, each new agricultural system can have an economic, social, or environmental impact. To this end, several studies

have been carried out on greenhouse crops in Biskra based on the socio-economic status of farms [16,27]. However, the sustainability of the protected cropping system has not yet been assessed. Given the income generated by the greenhouse cropping system, farmers have been convinced that increasing profits requires the implementation of intensive farming practices based on high doses of chemical inputs and abundant irrigation despite the damage done to certain social and environmental dimensions. Recently, some researchers have taken an interest in the sustainability of this production system.

According to a study by [38], a greenhouse in southeast Algeria shows strong economic and social sustainability, whereas environmental indicators show the opposite. These results are due to the lack of environmental farming practices implemented by the farmers. For instance, we can cite the high number of passes when working the soil (the number of passes by mechanical tools can reach eight times per season, which will negatively affect the biological and physical structure of the soil). [39] attest that soil compaction is mainly (70%) caused by narrow, high-pressure tyres. Also, excessive water consumption is the main cause of groundwater depletion. In recent times, a reduction in water depth has been recorded in the municipalities of Lioua and M'ziraa. In addition, the intensification of chemical inputs (fertilisers and pesticides) can harm human health and the environment, which is why [40] noted that excessive use of fertilisers could contribute to problems of eutrophication, acidification, and toxic contamination of soil, water, and air. These results are confirmed by a recent study carried out by [27] on the hot pepper value chain in the Biskra region.

Biskra is one of the Saharan regions where agricultural policies have led to spectacular agricultural development. From the 1980s, drilling techniques became widespread, and their cost fell considerably, leading to a phenomenal increase in the number of individual boreholes, the basis for the development of a new form of Saharan agriculture outside the oases, which is intensive and totally market-oriented [41]. The region has more than 100 thousand hectares under irrigation, but the exact number of boreholes in use is unknown. The local branch of the southern river basin agency estimates the total number of boreholes in the region at 17 thousand, of which only 8 thousand have been drilled with the authorisation of the relevant authorities [42]. However, this increase in the number of individual boreholes raises concerns about the risk of over-exploitation of groundwater and refocuses the debate on agricultural development in arid regions around the issue of water governance as a necessary condition for the sustainability of these activities [43,44]. The risk associated with the overexploitation of groundwater (in the sense of abstraction in excess of recharge) requires governance to be put in place to ensure efficient, equitable, and sustainable allocation of the resource [45–47].

6. Discussion

The agricultural policies put in place have been successful in promoting agricultural development in the Saharan regions of Algeria [7,8,16,18]. This success has had a significant effect on greenhouse market gardening, and the Biskra region has become an inspiring example of the effectiveness of greenhouse production under difficult climatic conditions [7,16]. This paper shows that farmers in our sample who used the PNDA to acquire land and invest in greenhouses are more likely to be less specialized in greenhouse production. It follows that the access to public support (i.e., the PNDA) is used more by farmers who prefer to diversify their agricultural production as this program does not specialize solely in greenhouse crops but is also related to other crops such as date palms [5], cereals, olive growing and milk production [48]. It is likely that the public support effort is effective in implementing greenhouse production but not in stimulating greenhouse specialization. Consequently, policymakers need to strengthen their efforts to implement farmers' specialization. In line with the literature, this study finds that, while it is true that the public authorities have intervened massively to support agricultural investments, in particular greenhouse crops with all their advantages and benefits, the greenhouse share of the surveyed farms is still unsatisfactory in relation to the total area of the farms. Another

particularly interesting result of the analysis is the small amount of farmland used by most greenhouse growers. This may explain why farms with other types of production (e.g., date palms and cereal crops) must have a large surface area. According to [9], the importance of date palms for farms in the Biskra region is due to their perfect adaptation to local climate and soil. The importance of cereal growing is also due to subsidies for seeds and fertilisers and the guaranteed purchase of the product by the State. As for the small area devoted to greenhouse crops, their intensive nature is a reward for the small size of their surface area. As for [9,19], this small area is due to the method of financing the farms, where greenhouse growers depend largely on their own financing, which reduces their investment capacity. In addition, the availability and affordability of water is one of the main constraints limiting the agricultural area used due to the need to irrigate all crops in this region.

Today, as a result of economic development, the way in which land is farmed is changing considerably. However, the small size of some farms is the result of the high cost of production factors (i.e., water and land), which has forced owners of large areas to invest in renting out their land. This has led to the emergence of a new form of farmland management, the indirect tenancy system [10,20,49]. The landowner generally has an interest in giving the worker a share of the production, according to a formula that varies from 1/3 to 1/4 of the profit made, which makes him a partner whose essential role is to do the cultivation work, while all the expenses belong to the landowners, and the working relationship is materialized between the landowner and the tenant by a contract. Recent works on agrarian contracts in Algeria [13,15,19–21,49–52] show that they have played a role in alleviating the difficulties of accessing land ownership (e.g., high purchase price, undivided status, etc.) and have played a significant role in agricultural and land dynamics. These transactions have contributed to the development of agricultural dynamics that are beneficial to local and sometimes regional economies [15,19,21]. These contracts have provided access to land for private investors with capital and landless farmers with technical innovations and have also indirectly accelerated the agricultural development launched by the agricultural land ownership and concession program in arid and semi-arid regions [13,19]. For instance, the sharecropping contract enables landless farmers (i.e., young beginners or people with know-how) to enter the market-gardening system and accumulate the productive resources they need (financial capital, managerial capital, social and relational networks, etc.) to become farmers. This has attracted many farmers with off-farm incomes who are known to have technical skills and long experience in greenhouse crop production to set up in the region.

Moreover, in the context of agriculture in the Biskra region, another possible reason for a greater involvement in the development of greenhouse crops is the farmer's know-how (experience). As an example, the young investors from the northern regions (e.g., Tipaza region) are known for their expertise in greenhouse tomato cultivation. Since their arrival, they have specialized in multi-chapel greenhouses, the Canary greenhouses of Spanish origin drawing on Moroccan technical expertise [53]. Indeed, our results show that previous experience matters as those farmers who have already made good profits from greenhouse production and have the know-how are more inclined to continue along this path. Hence, the experience can be seen as an investment for the farmer.

In addition, the level of education of farmers also plays a very important role. This shows that those with a lower level of education are less inclined to invest more in innovation, such as greenhouse production, for which more knowledge is needed. This result is confirmed by [54], showing that farm performance increases with increased levels of education. One explanation could be that using the most modern tools effectively requires specialized training and manual reading to generate a product with a higher market value. Furthermore, Refs. [55,56] confirmed that a higher level of education improves agricultural productivity. Ref. [57] has also confirmed that an improvement in the level of education of the farm manager in one year translates into an increase in farmers' income.

7. Conclusions

In conclusion, agricultural policies in the Biskra region seem not to play a significant role in the specialisation of farmers in greenhouse crops, while they are mainly used by farmers as a means to diversify their production and include greenhouses in their farms. Despite the initiatives and measures taken by the authorities to promote this practice, the results remain mixed, and the economic potential of greenhouse farming remains under-exploited. Several factors explain this situation. Firstly, the PNDA aims to support and promote agricultural development as a whole. As such, subsidies and incentives might not be sufficiently attractive to encourage a deeper transition to this more intensive and technologically advanced type of agriculture. In addition, the infrastructure needed to develop this practice, such as access to water, electricity, and modern equipment, remains inadequate in many of the development areas in the Biskra region. This might limit several farmers from fully engaging in greenhouse cultivation and reap significant benefits. Finally, it is important to note that agricultural policies must consider the particularities and specificities of each region, as one-size-fits-all approaches cannot be effectively applied to diverse agricultural environments such as the Biskra region. If the objective of the government is to encourage farmers to specialise in greenhouse crops, additional and/or complementary agricultural policies that encourage and support the development of greenhouse farming should be put in place. This could include more targeted subsidies for the installation of greenhouses, tax incentives for agricultural businesses involved in greenhouse specialisation, or research and development programmes aimed at improving greenhouse production techniques. In this context, the State has begun to reinforce its investments in the Biskra region by building new water points, using solar energy, acquiring water-saving irrigation equipment, acquiring new greenhouses, and supplying the new perimeters with electrical energy through the two agricultural development programmes (i.e., R'fig and ETTAHADI). According to the Ministry of Agriculture, in 2022, more than a thousand investment files will be granted to farmers, with a total amount exceeding 6 billion dinars. Nevertheless, greenhouse crops represent a promising approach to meeting the agricultural challenges of the future. With greater efforts to incorporate technological advances and make this method accessible to all, greenhouse growth could play a crucial role in building a sustainable future for agriculture in Algeria. However, it is essential to continue and expand research in this area. Specifically, it will be important to continue monitoring the use of the PNDA and similar policies by farmers since, in a dynamic context, the type of farms benefiting from State subsidies may change. In addition, it will be important to understand whether farms will be able to survive and operate without State subsidies in the future. As far as the sustainability of greenhouse crops is concerned, the development of a tool to assess the sustainability of greenhouse farming in arid regions now seems necessary to support the changes in farming practices that will ensure their sustainability. This will provide decision-makers, managers, and politicians with a clearer picture of the projections for the development of agriculture in a fragile environment evolving in a difficult climatic context. Also, it seems necessary to carry out in-depth studies in this area to be able to accurately assess the current state of the environment, e.g., by quantifying pesticide residues in cultivated vegetables, soil, and groundwater. Hasty agricultural development to meet immediate and urgent needs could have disastrous long-term consequences for the soil and groundwater reserves, whose renewal will be increasingly uncertain in the face of global warming.

Author Contributions: Conceptualization, T.A., L.C. and E.G.; methodology, L.C. and E.G.; formal analysis, L.C. and E.G.; investigation, T.A.; data curation, T.A.; writing—original draft, T.A.; writing—review & editing, L.C. and E.G.; visualization, T.A.; supervision, S.E.B. and A.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Ethical review and approval were waived for this study.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Foley, J.A.; Defries, R.; Asner, G.P.; Barford, C.; Bonan, G.; Carpenter, S.R.; Chapin, F.S.; Coe, M.T.; Daily, G.C.; Gibbs, H.K.; et al. Global consequences of land use. *Science* **2005**, *309*, 570–574. [CrossRef] [PubMed]
2. Godfray, H.C.J.; Beddington, J.R.; Crute, I.R.; Haddad, L.; Lawrence, D.; Muir, J.F.; Pretty, J.; Robinson, S.; Thomas, S.M.; Toulmin, C. Food security: The challenge of feeding 9 billion people. *Science* **2010**, *327*, 812–818. [CrossRef] [PubMed]
3. FAOSTAT. Site Web de la Base Statistique de la FAO. 2020. Available online: <https://www.FAO.org> (accessed on 2 July 2023).
4. Moussaceb, N.; Tighzer, T. Impact du Secteur Agricole sur la Croissance Economique en Algérie. Master's Thesis, Université Abderrahmane Mira, Bejaia, Algeria, 2017; p. 120.
5. Benziouche, S.E. Les impacts socioéconomiques du PNDA dans la vallée d'Oued Righ. *El-Bahith Rev.* **2007**, *5*, 1–5.
6. Benziouche, S.E.; Chehat, F. Irrigation problem in Ziban oases (Algeria): Causes and consequences. *Environment, Development and Sustainability. Environ. Dev. Sustain.* **2018**, *21*, 2693–2706. [CrossRef]
7. Bouammar, B. Le Développement Agricole Dans les Régions Sahariennes. Etude de cas de la Région d'Ouargla et de la Région de Biskra (2006–2008). Ph.D. Thesis, Université Kasdi Merbah, Ouargla, Algeria, 2010; p. 7.
8. Ababsa, S. *Introduction au Cours de Socio-Economie de Développement des Régions Sahariennes*; INFS/AS: Ouargla, Algeria, 2002; p. 113.
9. Belhadi, A.; Mehenni, M.; Reguieg, L.; Yekhlief, H. Apport de la plasticulture au dynamisme agricole de la région des Ziban-Biskra. *Rev. Agric.* **2016**, *1*, 93–99.
10. Hadeid, M.; Sid Ahmed, B.; Ghodbani, T.; Dari, O. L'agriculture au Sahara du sud-ouest algérien: Entre développement agricole moderne et permanences de l'agriculture oasienne traditionnelle. *Cah. Agric.* **2018**, *27*, 1–8. [CrossRef]
11. Bessaoud, O. La question foncière au Maghreb: La longue marche vers la privatisation. *Cah. CREAD* **2013**, *103*, 17–44.
12. Baroud, K.; Colin, J.P.; Daoudi, A. La politique d'accès à la propriété privée des terres mises en valeur en zones arides en Algérie. *Éléments de discussion. Econ. Rural* **2018**, *363*, 81–98. [CrossRef]
13. Daoudi, A.; Colin, J.P. Construction et transfert de la propriété foncière dans la nouvelle agriculture steppique et saharienne en Algérie. In *Propriété et Société en Algérie Contemporaine*; Guignard, D., Ed.; Iremam, Open Edition Books: Aix-en-Provence, France, 2017; pp. 158–176. [CrossRef]
14. Daoudi, A.; Colin, J.P.; Baroud, K. La politique de mise en valeur des terres arides en Algérie: Une lecture en termes d'équité. *Cah. Agric.* **2021**, *30*, 4. [CrossRef]
15. Amichi, F.; Bouarfa, S.; Lejars, C.; Kuper, M.; Hartani, T.; Daoudi, A.; Belhamra, M. Des serres et des hommes: Des exploitations motrices de l'expansion territoriale et de l'ascension socioprofessionnelle sur un front pionnier de l'agriculture saharienne en Algérie. *Cah. Agric.* **2015**, *24*, 11–19. [CrossRef]
16. Daoudi, A.; Lejars, C. De l'agriculture oasienne à l'agriculture saharienne dans la région des Ziban en Algérie. *Acteurs du dynamisme et facteurs d'incertitude. New Médit* **2016**, *15*, 45–52.
17. Daoudi, A. Le financement informel du secteur maraîcher en Algérie: Le cas du crédit fournisseur. *Téch. Financ. Dév.* **2016**, *124*, 107–116. [CrossRef]
18. Daoudi, A. La néo-agriculture saharienne: Entre mirages et réalités. In Proceedings of the Webinaire Torba/GRFI-Filaha Innov 2021, Thème: Capitaliser et Partager des Connaissances sur l'Agriculture Saharienne, Online, 1–14 October 2021; pp. 51–58.
19. Daoudi, A.; Colin, J.P.; Derderi, A.; Ouendeno, M.L. Le marché du faire-valoir indirect vecteur de nouvelles formes d'exploitation dans la néo-agriculture saharienne (Algérie). *Géographie Économie Société* **2017**, *19*, 307–330. [CrossRef]
20. Boudibi, S.; Sakaa, B.; Benguega, Z. Spatial variability and risk assessment of groundwater pollution in El-Outaya region, Algeria. *J. Afr. Earth Sci.* **2021**, *176*, 104135. [CrossRef]
21. Sedrati, N. Origines et Caractéristiques Physico-Chimiques des Eaux de la Wilaya de Biskra-Sud-Est-Algérien. Ph.D. Thesis, Badji Mokhtar-Annaba University, Annaba, Algeria, 2011.
22. Boudibi, S. Modeling the Impact of Irrigation Water Quality on Soil Salinization in an Arid Region, Case of Biskra. Ph.D. Thesis, Mohamed Khider University of Biskra, Biskra, Algeria, 2021; p. 175.
23. Halilet, M.T. Étude Expérimentale de Sable Additionnée d'Argile. Comportement Physique et Organisation Saline et Sodique. Ph.D. Thesis, I.N.A.P.G., Paris, France, 1998; 250p.
24. Naouri, M.; Hartani, T.; Kuper, M. Mobilités des jeunes ruraux pour intégrer les nouvelles agricultures sahariennes (Biskra, Algérie). *Cah. Agric.* **2015**, *24*, 379–386. [CrossRef]
25. Ouendeno, M.L.; Daoudi, A.; Colin, J.P. Les trajectoires professionnelles des jeunes dans la néo-agriculture saharienne (Biskra, Algérie) revisitées par la théorie de l'agricultural ladder. *Cah. Agric.* **2015**, *24*, 396–403. [CrossRef]
26. Aidat, T.; Benziouche, S.E. Greenhouse crops in biskra (algeria), situation, constraints, and producers' strategies (m'ziraa and el-ghrous regions). *Ponte J.* **2020**, *76*, 32. [CrossRef]

27. Benziouche, S.E. *Analyse de la Chaîne de Valeur «Piment» Dans la Wilaya de Biskra. Rapport de Mission. Programme d'Appui au Secteur Agricole (PASA) au Pôle Sud: Biskra et El Oued*; AFC Agriculture and Finance Consultants GmbH (AFC): Bonn, Germany, 2021.
28. Assassi, S.; Daoudi, A.; Lejars, C. Les profits « excessifs » des commerçants de fruits et légumes en Algérie: Réalité ou préjugé infondé ? Le cas de la tomate primeur à Biskra. *Cah. Agric.* **2017**, *26*, 25002. [[CrossRef](#)]
29. DSA Biskra. *Rapport de l'Activité Agricole de la Direction de Service Agricole de la Wilaya de Biskra-Algérie*; DSA Biskra: Biskra, Algeria, 2020.
30. Khiari, A. Une région pionnière dans le Sahara algérien: El Ghrouss. *Méditerranée* **2002**, *99*, 27–30. [[CrossRef](#)]
31. Aidat, T.; Benziouche, S.E. Situation and Environmental Impacts of Phytosanitary Treatments for Greenhouse Vegetable Crops in the Region of Biskra (ALGERIA). In *Recent Advances in Environmental Science from the Euro-Mediterranean and Surrounding Regions*, 2nd ed.; Environmental Science and Engineering; Springer International Publishing: Cham, Switzerland, 2021; p. 1431.
32. Alletto, L.; Coquet, Y.; Benoit, P.; Heddad, D.; Barriuso, E. Tillage management effects on pesticide fate in soils. A review. *Agron. Sustain. Dev.* **2010**, *30*, 367–400. [[CrossRef](#)]
33. Dusfour, I.; Achee, N.L.; Briceno, I.; King, R.; Grieco, J.P. Comparative data on the insecticide resistance of *Anopheles albimanus* in relation to agricultural practices in northern Belize, CA. *J. Pest. Sci.* **2010**, *83*, 41–46. [[CrossRef](#)]
34. Huang, S.; Wang, L.; Liu, L.; Fu, Q.; Zhu, D. Nonchemical pest control in China rice: A review. *Agron. Sustain. Dev.* **2014**, *34*, 275–291. [[CrossRef](#)]
35. Kanda, M.; Wala, K.; Batawila, K.; Djaneye-Boundjou, G.; Ahanchede, A.; Akpagana, K. Le maraîchage périurbain à Lomé: Pratiques culturelles, risques sanitaires et dynamiques spatiales. *Cah. Agric.* **2009**, *18*, 356–363. [[CrossRef](#)]
36. Aminata, D.; Lota, D.T.; François, S.F. Factors Explaining the Dynamics of Agricultural Technological Innovations Adoption: Evidence from Senegal's Rain Maize Farmer. *J. Agric. Sci.* **2022**, *13*, 1234–1258.
37. Kassa, B.A.; Abdi, A.D. Factors influencing the Adoption of Climate-Smart Agricultural Practice by Small-Scale Farming Households in Wondo Genet, Southern Ethiopia. *SAGE Open* **2022**, *12*, 1–13. [[CrossRef](#)]
38. Benchikh, A. Intensification et Mise en Valeur Pour une Agriculture Durable Dans les Régions Arides: Cas de la Wilaya de Biskra. Ph.D. Thesis, Ecole Nationale Supérieure Agronomique (Ensa) El Harrach, Alger, Algeria, 2017.
39. Walter, C.; Stützel, H. A new method for assessing the sustainability of land-use systems (II): Evaluating impact indicators. *Ecol. Econ.* **2009**, *68*, 1288–1300. [[CrossRef](#)]
40. Hayati, D.; Ranjbar, Z.; Karami, E. Measuring Agricultural Sustainability. In *Biodiversity, Biofuels, Agroforestry and Conservation Agriculture*; Lichtfouse, E., Ed.; Sustainable Agriculture Reviews; Springer: Dordrecht, The Netherlands, 2011; Volume 5, pp. 73–101.
41. Mubarak, J.A. Middle East and North Africa: Development policy in view of a narrow agricultural natural resource base. *World Dev.* **1998**, *26*, 877–895. [[CrossRef](#)]
42. Daoudi, A.; Lejars, C.; Benouniche, N. La gouvernance de l'eau souterraine dans le Sahara algérien: Enjeux, cadre légal et pratiques locales. *Cah. Agric.* **2017**, *26*, 4–8. [[CrossRef](#)]
43. Kuper, M.; Fayse, N.; Hammani, A.; Hartani, T.; Marlet, S.; Hamamouche, M.F. Liberation or anarchy? The Janus nature of groundwater use on North Africa's new irrigation frontiers. In *Integrated Groundwater Management*; Jakeman, T., Barreteau, O., Hunt, R., Rinaudo, J.D., Ross, A., Eds.; Springer: Dordrecht, The Netherlands, 2016; pp. 583–615.
44. Petit, O.; Kuper, M.; López-Gunn, E.; Rinaudo, J.D.; Daoudi, A.; Lejars, C. Can agricultural groundwater economies collapse? An inquiry into the pathways of four groundwater economies under threat. *Hydrogeol. J.* **2017**, *25*, 1549–1564. [[CrossRef](#)]
45. Petit, O. La surexploitation des eaux souterraines: Enjeux et gouvernance. *Nat. Sci. Soc.* **2004**, *2*, 146–156. [[CrossRef](#)]
46. Llamas, M.; Martinez-Santos, P. Intensive groundwater use: Silent revolution and potential source of social conflicts. *J. Water Resour. Plan. Manag.* **2012**, *131*, 337–341. [[CrossRef](#)]
47. Jenifer, A.; Arul, C. Groundwater management: A policy perspective. *World Academy of Science. Eng. Technol.* **2012**, *62*, 303–310.
48. Chedded, M.A. *Analyse de l'Impact des Investissements Agricole Réalisés Dans le Cadre du Plan National de Développement Agricole (PNDA) sur Evolution des Techniques de Productions Laitières, Céréalières et Oléicoles en Algérie: Etude de cas Dans la Wilaya de Tizi-Ouzou*. Ph.D. Thesis, Académie D'aix Marseille, Université D'Avignon Et Des Pays De Vaucluse, Avignon, France, 2015.
49. Colin, J.-P. Contrats agraires ou conventions agraires? *Écon. Rural* **2002**, *272*, 57–72. [[CrossRef](#)]
50. Amichi, H.; Bazin, G.; Chehat, F.; Ducourtieux, O.; Fusillier, J.-L.; Hartani, T.; Kuper, M. Enjeux de la recomposition des exploitations agricoles collectives des grands périmètres irrigués en Algérie: Le cas du Bas-Cheliff. *Cah. Agric.* **2011**, *20*, 150–156.
51. Bouchaib, F.; Donguey, M.-D.; Jouve, A.-M. Le développement du mode de faire-valoir indirect informel en Algérie. Cas du secteur public dans la Mitidja Ouest. *Opt. Méditer.* **2011**, *66*, 104–114.
52. Hamamouche, M.F.; Kuper, M.; Lejars, C. Émancipation des jeunes des oasis du Sahara algérien par le déverrouillage de l'accès à la terre et à l'eau. *Cah. D'agric.* **2015**, *24*, 412–419. [[CrossRef](#)]
53. Hartani, T.; Naouri, M.; Kuper, M. L'entrée des jeunes dans l'agriculture: Cas du maraîchage sous serre dans les Ziban (Algérie). *Altern. Rural.* **2015**, *10*, 5–8. [[CrossRef](#)]
54. Muhammad-Lawal, A.; Amolegbe, K.B.; Oloyede, W.O.; Lawal, O.M. Assessment of commercialization of food crops among farming households in Southwestern, Nigeria. *Ethiop. J. Environ. Stud. Manag.* **2014**, *7*, 520–531. [[CrossRef](#)]
55. Welch, F. *Returns to Scale in U.S. Agriculture, Education Information and Efficiency, Document de Travail, Série 1*; Center for Economic Analysis of Human Behavior and Social Institutions, National Bureau of Economic Research: Palo Alto, CA, USA, 1975.

56. Khaldi, N. Education and Allocative Efficiency in U.S. Agriculture. *Am. J. Agric. Econ.* **1975**, *57*, 650–657. [[CrossRef](#)]
57. Kafando, B. *Estimation des Effets de l'Education sur le Revenu Agricole: Cas des Ménages Agricoles du Milieu Rural de l'Inde*; Cahier de Recherche/Working Paper; Université de Sherbrooke: Sherbrooke, QC, Canada, 2020; p. 19.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.