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Climate-Smart Agriculture in Iran: Strategies, Constraints and Drivers

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Abstract: Although climate-smart agriculture can simultaneously decline greenhouse gas emissions, increase the adaptive capacity of farmers and improve food security under climate change, constraints and drivers of scaling up are not entirely addressed in developing countries. This qualitative case study was conducted on both strawberry growers and agricultural experts to explore the perceived causes, evidence and impacts of climate change, adaptation strategies used by farmers, and constraints and drivers of climate-smart agriculture development on the strawberry farms in Kurdistan province, Western Iran. Findings indicated that the causes of climate change could be divided into anthropogenic and natural forces. Decreased precipitation, increased temperature, dust storms, greenhouse gases, forest fires, spring frosts, severe hail, floods and droughts comprised the most notable climate change evidence in the region. Both groups confirmed the impacts of climate change on the reduction in strawberry yield, increasing the perishability of the fruits, poverty, migration and other social problems. Adaptation strategies used by farmers are classified into technical–agricultural, water conservation, farm smartening, and institutional adaptation practices. However, poverty, the shortage of strawberry-processing industries, insufficient financial support, the presence of intermediaries and brokers, traditional cultivation, difficulties in shipping strawberry crops to the market, the lack of storage facilities and equipment and the export terminal along with the mistrust of strawberry growers in the agricultural organization hinder climate-smart agriculture development in the study area. Finally, several drivers were proposed, which were considered the basis for providing practical suggestions for planning and policy making for climate-smart agriculture development in strawberry farms.

Keywords: climate change impacts; adaptive strategies; climate-smart agriculture; strawberry growers

Citation: Memarbashi, P.; Mojarradi, G.; Keshavarz, M. Climate-Smart Agriculture in Iran: Strategies, Constraints and Drivers. *Sustainability* **2022**, *14*, 15573. https://doi.org/10.3390/su142315573

Academic Editor: Donato Morea

Received: 21 September 2022
Accepted: 9 November 2022
Published: 23 November 2022

1. Introduction

In recent decades, rapid and sustained climate change, such as rising temperature and changes in precipitation, and its consequences (i.e., floods and droughts) have become a significant threat to the lives of millions of people around the world [1]. Climate change is defined as a shift in weather patterns over approximately 30 years, mainly caused by greenhouse gas emissions from natural systems and human activities [2]. While the destructive effects of climate change continue to increase, most of the damages are to developing countries whose people have a low capacity for the mitigation of disaster impacts or adaptation to these climatic risks [3]. Climate-change-induced disasters, such as floods, droughts, and severe storms, are major sources of income fluctuations for poor households that significantly rely on natural resources for their livelihoods [4–6]. In particular, these changes have affected the lives and survival of about 70% of the poor people living in rural areas, and their livelihoods depend mainly on agriculture, forestry, and fishing [7]. Given these consequences, for more than two decades, climate change studies have become one of the most important and challenging global issues. Most of these studies have recommended the adaptation option as an essential tool to improve the livelihood of socially vulnerable sectors [8,9]. Accordingly, governments in different countries are developing adaptation strategies, which are assumed to prepare a particular area or country for the impacts of climate change [10]. In this regard, in recent years, the concept of climate-smart agriculture (CSA) has been introduced as a way to manage agricultural systems and their practical response to climate change. Worldwide attention to this concept has led to the creation of a global alliance on CSA [11].

CSA was first introduced in 2010 by FAO at "the World Conference on Agriculture, Food Security and Climate Change" as a sustainable agricultural system that enhances productivity and sustainability in the face of climate change [12]. CSA involves using a wide range of activities, services, and technologies that seek to tackle three primary goals in the agricultural sector in the context of climate change. These goals include (1) helping to increase sustainable production of agricultural products and ensuring food security; (2) creating agricultural systems adaptable and resilient to climate change; and (3) reducing and/or removing greenhouse gas emissions, where possible [13]. Chandra et al. [14] divided CSA strategies into five groups: crop management, soil and water management, reclamation of degraded land and waste, market and technology management [13]. FAO also outlined some CSA approaches, including crop residue management, nutrition management, soil and water management, crop management, knowledge management, and integrated pest management [13]. Overall, the nature of CSA requires that a variety of options and strategies be developed and prioritized for different conditions and groups, taking into account its three basic dimensions [15]. For example, in small-scale, low-input farming systems in developing countries, activities that help increase yield, food security, and adaptability are more likely to take precedence over activities that help reduce greenhouse gas emissions and mitigate climate change. However, adapting to climate change and mitigating its negative impacts are complementary rather than alternative to each other, so it is not impossible to achieve three dimensions in practice [16].

Iran is one of the countries that has been significantly influenced by climate change because of its aridity. One of the most critical signs of climate change in Iran has been the change in rainfall pattern, which, along with various factors, such as population growth and improper pattern of water consumption, have imposed severe negative impacts on freshwater resources. For instance, per capita access to fresh water in the country was about 2000 cubic meters in 2000 [17], which is projected to decrease to 1500 cubic meters by 2030 [18]. Meanwhile, during the last three decades, Iran has witnessed the most severe and prolonged droughts of the century [18]. While agriculture in Iran is firmly under pressure due to population growth, increasing demand for food, and reducing fertile land [19], drought has also become a serious threat to this sector of the economy [20–22]. Most studies in the country have confirmed the negative impacts of climate change, particularly droughts, on the performance of the agricultural sector. For example, a study by [23] in Northeastern Iran showed a decrease in the period of planting to flowering, as well as an increase in the period of the physiological maturity of corn under climate change [24], with an economic analysis of climate change impacts on cotton productivity, concluded that increasing temperature during the growing season hurts cotton yield. This study showed that cotton yield in the country has had a downward trend due to climate change in recent years. Concerning garden products, extensive research has been conducted to evaluate the effect of climate change on the physiological processes (breathing, photosynthesis, flowering and reproductive) of these products. These research studies indicate that turning flowers into fruits is directly influenced by climate change [25]. Additionally, climate change affects the early stages of growth and flowering of these products [26]. High temperatures reduce plant hormones and the primary and secondary metabolism. It also reduces seed germination in fruits and vegetables. Ultraviolet effects also lead to anthocyanin production and changes in the genetic characteristics of herbal products and fruits [27].

Strawberry is one of the garden products that is heavily influenced by climate change [28]. The annual production of strawberries in the world has continually grown and doubled in the last twenty years [29]. In Iran, the level of strawberry cultivation is 4891 hectares, of which about 56,346 tons of products are harvested. In Kurdistan province, Western Iran, strawberry cultivation has been significantly increased during the last four decades. According to reports published by the Ministry of Agriculture, the cultivation of this product in Kurdistan province from 180 hectares in 1981 reached 3154 hectares in 2017. This province provides about 75 percent of the country's strawberry crops with an annual production of nearly 41,000 tons [30].

Despite the importance of strawberry production for Kurdistan province, climate change and fluctuations, such as floods, droughts, frost and hail, severe storms, heavy snowfall, and depletion of groundwater, have affected the yield of this crop in different years. For example, according to the Agriculture Organization of Kurdistan Province, due to spring cold and hail in 2018, 1200 hectares of strawberry farms in the province were damaged by 10 to 50 percent. In this regard, the long-term statistics of Kurdistan province from 1961 to 2013 show that this province has experienced precipitation with a decreasing slope of 3.54 mm per year, while the average temperature has had an increasing slope of 3 °C in all these years [31]. With attention to the trend of global warming and changes in rainfall patterns in the world, and according to some forecasts, by 2080–2099, the average temperature in Iran will increase by 3 to 4 °C [32]. This will create problems for the agriculture sector and, consequently, the livelihood of many strawberry growers in Kurdistan province.

Farmers' participation in CSA interventions seems necessary since CSA is an option for the sustainability of agricultural systems, ensuring food security, improving resilience and adaptation to climate change, and also reducing greenhouse gas emissions [33]. However, any initiative for the participation of farmers and the agriculture sector in CSA depends on recognizing strategies for it as well as understanding the constraints that exist for the development of CSA in practice. The strategies that farmers use to deal with climate change, as well as the barriers to applying these strategies in practice, vary depending on the product and the region [34]. However, the best way to identify these strategies and barriers is to explore them by discussing with farmers who are the main stakeholders in the agricultural sector, the most involved with the farm environment, and closely touching challenges facing agriculture. In addition to farmers, agricultural experts and managers are other groups who have valuable information about what is happening in the agricultural sector and the organizational factors affecting it. At the same time, these people are also directly or indirectly influential in decisions and policy making. So, this study was conducted to explore practical strategies for the mitigation of climate change impacts, and also constraints and drivers for CSA implementation in the strawberry farms from the viewpoint of strawberry growers and agricultural experts as the two closest groups involved in the agricultural activities. In line with the above objectives, the study also investigated geographical features and strawberry cultivation method in the study area, water sources used for irrigation, labor force situation for strawberry cultivation, and causes, evidence and impacts of climate change in the study area. The manuscript is structured as follows. Section 2 explains the research method designed to investigate the research objectives and introduces the study area. Section 3 presents the findings of the study, and the final section contains a conclusion that provides a basis for the development of management policies and strategies to expand the use of CSA by strawberry growers and corporate sectors involved in the production of this horticultural product.

2. Research Method and Case Study Description

2.1. Case Study Area

This study was conducted in Kurdistan province, located in Western Iran. The area of this province is 29,137 km^2, which is equivalent to 1.7 percent of the country's total area. The province has 10 cities and 86 rural areas. The population of this province is 1,658,000 of which 66 percent are living in cities and 34 percent in villages [35]. Climatically and naturally, Kurdistan province is a mountainous region with cold to temperate climates. The average rainfall in this province is 519 mm, and the average temperature is 12.5 °C [36].

Economically, Kurdistan province is highly dependent on agriculture, and out of 114,000 farmers in the agricultural sector, 99.6% of them are engaged in at least one of the activities of agriculture, horticulture, greenhouse production, animal husbandry, and poultry farming in the traditional way. The area of agricultural lands of this province is about 1,052,000 hectares, 97.3% of arable lands, and the rest, equal to 2.7%, belong to gardens. In the 2016–2017 crop year, the area under annual crop cultivation was 747,591 hectares, of which 12.3% was irrigated, and 87.7% was rainfed [37]. Figure 1 indicates the province's position in terms of the distribution of agricultural areas. As mentioned in the introduction, Kurdistan province was selected as the study area because it is the center of strawberry production in Iran.

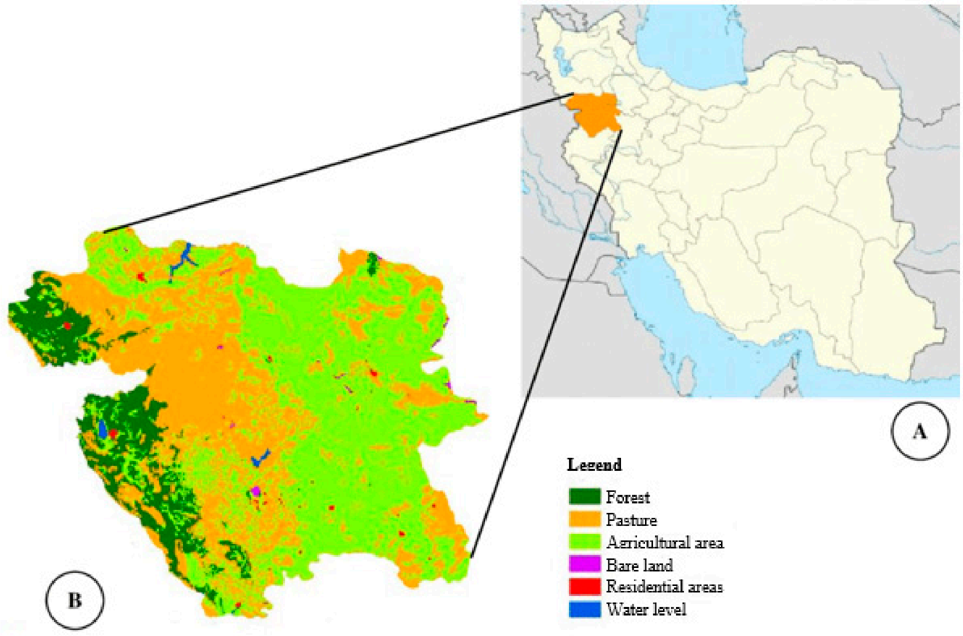

Figure 1. (**A**) Map of Iran. (**B**) Map of land use in Kurdistan province [37].

2.2. Method

Identifying CSA practices and technologies for the mitigation of climate change impacts and constraints for its implementation has a complex and exploratory nature. Therefore, a qualitative approach (i.e., case study) was applied to explore it. The study populations were strawberry growers and experts (including managers and experts in Agricultural Organization of Kurdistan Province, faculty members of the University of Kurdistan and Strawberry Breeding and Agronomic Research Institute of this university, experts of Agricultural and Natural Resources Research and Education Center, Meteorological Bureau, and Agricultural and Natural Resources Engineering Organization of Kurdistan province), who are somehow involved in the process of strawberry production in Kurdistan province and the climate issues of this province.

In order to select participants, the critical sampling method was used in the first stage (including informed and key farmers and experts) and the snowball sampling method in the second stage (including farmers and experts introduced by other research participants). In total, 30 strawberry growers and 32 experts were interviewed between June and July 2021. The important variables that were investigated included geographical features and the strawberry cultivation method in the study area, water sources used for irrigation, labor force situation for strawberry cultivation, causes, evidence and impacts of climate change in the study area, practical strategies for mitigation of climate change impacts and constraints of CSA implementation in the strawberry farms. The data collection process continued until theoretical saturation (i.e., repetition of answers and finding no new concepts). The average length of the interviews with strawberry growers was about 42 min, ranging between 25 and 60 min. Additionally, the average length of the interviews with experts was 34 min, ranging between 25 and 45 min. Overall, the interviews lasted more than 39 h. In order to evaluate the validity of the research, the data triangulation method, which is always emphasized in increasing the validity of qualitative research [38], was used. In this regard, data were collected from different sources, and various methods, including observation and studying documents, were used along with semi-structured interviews. In addition, the findings were confirmed through reviewing and giving feedback from various researchers and experts. In order to ensure the reliability of the research, the technique of taking notes and recording the voices of the interviewees (with their consent) was used in the data collection stage. The transcribed interviews were coded and analyzed with the software MaxQDA Version 2011 under the supervision of specialists, so that the views of the researchers did not affect the data analysis [39]. The use of these methods helped to increase the coherence and reliability of the data collected.

3. Results and Discussion

3.1. Demographic Characteristics of the Participants

Demographic characteristics of the respondents in Table 1 indicate that the average age of strawberry growers was 48 years and that of experts was 42 years. Three (10%) strawberry growers and six experts (18.75%) were women, and the rest of the interviewees were men. Regarding marital status, 20 strawberry growers and 17 experts (59.67% in total) were married, and the rest (40.33% in total) were single. The average work experience in agriculture for strawberry growers was 30 years, and that for experts was 17 years. In terms of education level, 2 strawberry growers (6.67%) were illiterate and without the ability to read and write, 11 (36.67%) had primary education, 1 (3.33%) had secondary education, 7 (23.33%) had Diploma, and 9 (30%) strawberry growers had a university education. As can be seen in Table 1, all experts had a university degree.

Table 1. Demographic characteristics of the participants (n = 62).

Variable	Levels	Strawberry Growers (n = 30)		Experts (n = 32)	
		Frequency (%)	**Mean (Std. Deviation)**	**Frequency (%)**	**Mean (Std. Deviation)**
Age			48 (6.03)		42 (7.12)
Work experience			30 (3.15)		17 (2.33)
Gender	Male	27 (90)		25 (81.25)	
	Female	3 (10)		6 (18.75)	
Marital status	Married	20 (66.67)		17 (53.13)	
	Single	10 (33.33)		15 (46.87)	
Education level	Illiterate	2 (6.67)		-	
	Primary education	11 (36.67)		-	
	Secondary education	1 (3.33)		-	
	Diploma	7 (23.33)		-	
	University degree	9 (30)		32 (100)	

3.2. Geographical Characteristics, Water Resources and Strawberry Crop Cultivation Methods in the Study Area

As shown in Table 2, the climate of the study area is cold and mountainous, and the soil texture of strawberry farms is often light. Additionally, the dominant method of strawberry cultivation is open field cultivation, and only three strawberry growers cultivated in both open fields and greenhouses. Strawberry growers believed that "*Establishing a* *greenhouse requires much capital, and farmers in the area are unable to do so due to their poor economic situation*". In addition, "*The government does not provide enough facilities to establish a greenhouse, or if it does, many pre-requesting conditions should be provided. As a result, almost no farmers will be able to receive them*". The most critical water resources used for irrigation of strawberry crops are wells; however, several farmers irrigated their farm using the river, natural spring, and wastewater. The results also showed that the labor force situation for strawberry cultivation is more in the form of family labor, and fewer workers are hired in farm work. This is often due to the high labor wages, which deprived poor or smallholder farmers of their support. Additionally, some of the hired workers do not work as efficiently as family labor, and therefore, they may not have enough benefits on the farm. Moreover, in some cases, workers are not available. These findings are congruent with the findings of [40], who found that family provides most or all of the labor needed on the small farms in developing and low-income countries.

Table 2. Geographical features, water resources, cultivation method and labor force situation for strawberry cultivation in the study area.

Category (Based on Axial Coding)	Code (Based on Open Coding)	Frequency
Geographical features	Cold and mountainous climate	20
	Light texture of soil in the strawberry farms	8
Strawberry cultivation method	Open field cultivation	15
	Greenhouse cultivation	3
Water resources for irrigation	Well	7
	River	6
	Natural spring	6
	Untreated wastewater and unconventional water	2
Labor force situation for strawberry cultivation	Family labor	20
	Worker	6

3.3. Causes, Evidence and Impacts of Climate Change as Perceived by Farmers and Agricultural Experts

3.3.1. Causes of Climate Change

Figure 2 shows the interviewees' perception regarding the causes of climate change in the study area. Thirty respondents or about 48% of the respondents (nine strawberry growers and twenty-one experts) believed that anthropogenic forces, such as human intervention in nature had caused extreme climate change in the study area. High rates of deforestation, overgrazing, uncontrolled groundwater extraction, population growth, and overuse of fertilizers and chemical pesticides were identified as major anthropogenic causes of climate change. For example, farmers stated that "*Overgrazing of livestock and degradation of pastures has led to an increase in runoff and flooding compared to the past*". As state by [41], the increasing number of light and heavy livestock in the study area and difficulty of providing the required fodder, as well as neglecting the real value of pastures by people, can be considered the main reasons for indiscriminate grazing. Additionally, an expert believed that "*Unauthorized well drilling by farmers has dried up rivers and surface water resources and caused climate change*". In this regard, according to the reports provided by [42], the number of wells that have been dug illegally is increasing in the province such that currently, there are about 8000 unauthorized wells in this province, most of which are dug for personal gain in the construction of private villas and gardens. Regarding the phenomenon of deforestation, according to the report of [43], in the first half of 2022, 6711 cases of deforestation were reported to this organization, and from this point of view, Kurdistan province ranks second in deforestation in the country. It seems that the main cause of deforestation in Kurdistan is economic underdevelopment and lack of environmental culture; on the other hand, excessive water harvesting and forest fires in summer are also other main reasons for deforestation in this region [41].

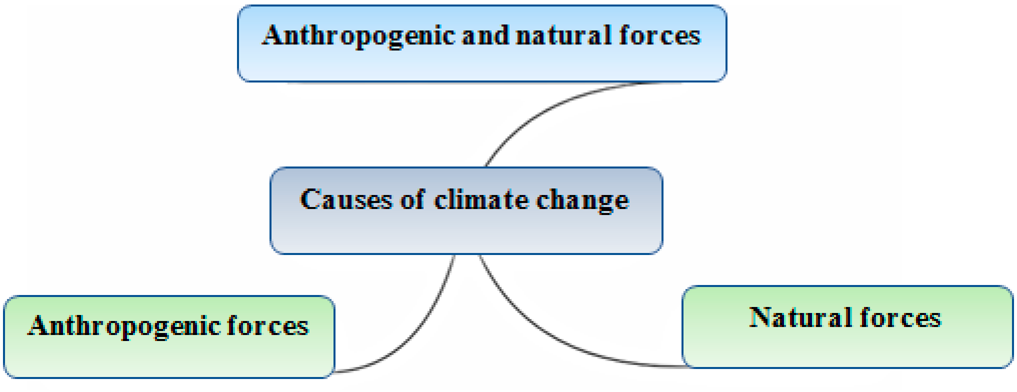

Figure 2. Causes of climate change from viewpoint of strawberry growers and experts; Note: The general causes of climate change mentioned in the literature review are shown in blue. Causes of climate change in the study area is shown in dark blue. The green color is the the opinions of strawberry growers and experts in common about causes of climate change.

Overall, participant's perception of the anthropogenic causes of climate change was in agreement with the studies by [34,44,45], who recognized deforestation, rapid population growth, and poor soil and water management as common climate change causes. In addition to anthropogenic forces, about 11% of the respondents (two strawberry growers and five experts) considered climate change as a natural phenomenon. Eight experts believed that climate change results from both anthropogenic and natural forces. Farmers who considered climate change as the result of natural factors looked at this phenomenon from a fatalist view and believed that "*the Rain or snowfall will come just as God deems it advisable. Drought will also end whenever God makes a will*". This finding is consistent with [46]. In contrast, the studied experts looked at the natural causes of climate change with a scientific perspective and considered factors such as changes in the Earth's orbit and rotation, absorption of the Sun's energy, changes in naturally occurring carbon dioxide concentrations, and variations in solar activity as the natural causes of climate change.

3.3.2. Evidence of Climate Change

Figure 3 shows evidence of climate change from the viewpoint of the farmers and experts. As can be seen in this figure, a decrease in precipitation with 47 (about 76% of all respondents), an increase in temperature with 32 (about 52% of all respondents), and a decrease in groundwater with 13 frequencies (about 21% of all respondents) were the agreed evidence of climate change. These findings are in agreement with the results of studies by [45] in Ethiopia, which reported variability in rainfall and increase in temperature as the most indicators of climate change, among others. The decrease in rainfall in Kurdistan province has been emphasized in various reports in recent years. For example, according to the report of [47], the average rainfall in the first six months of 2022 was about 111 mm, which shows a decrease of about 24% compared to the same long-term period. According to this report, this decrease in rainfall in many areas of the province has caused mild to severe drought. Farajzadeh and Elahi [48] investigated climate change in Kurdistan province using meteorological data for a period of 58 years from 1960 to 2017. The findings of this study showed that the overall average temperature in this province was increasing during this period, although in some months of the year, drastic decrease changes were seen in the average temperature and the minimum average.

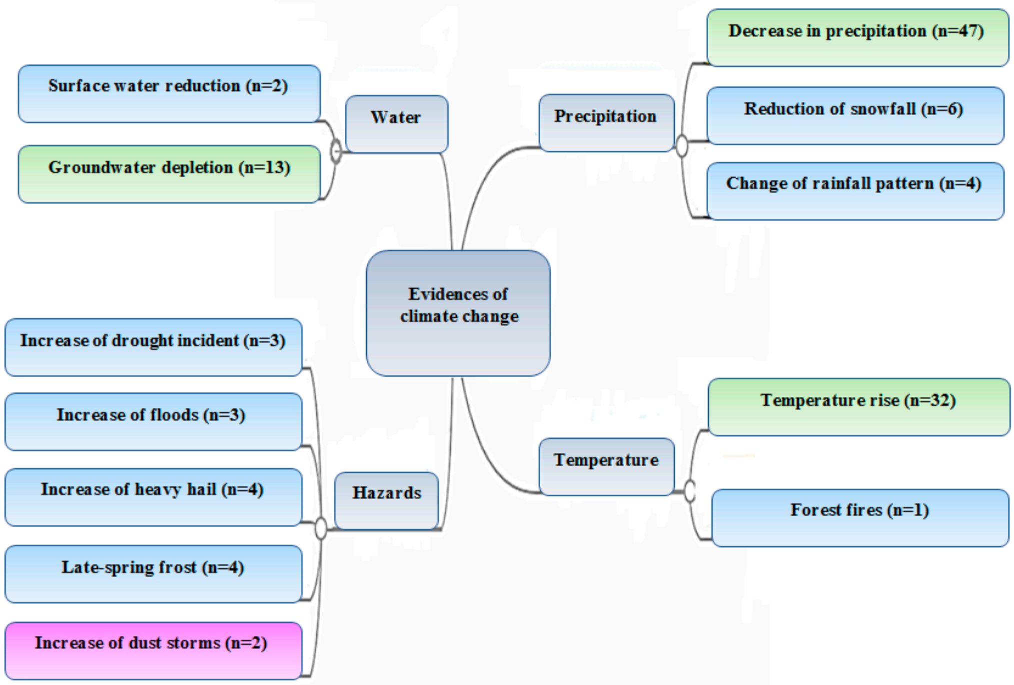

Figure 3. Evidence of climate change from the viewpoint of strawberry growers and experts. Note: Findings from strawberry growers are shown in purple, experts in blue and common results in green. Dark blue shows evidence of climate change in different parts (including water, precipitation, temperature and hazards).

In addition to this common evidence, two strawberry growers cited increasing dust storms as another sign of climate change in the study area. They emphasized that "*Since the rain and snowfall have decreased, the dust in the area has also increased due to the dryness of the air and the surrounding lands. The drying up of the plains in Iraq also brings all the dust to our region*". This finding is in line with [49,50], which reported increasing dust storms in western provinces of Iran. Experts also pointed to other evidence of climate change, such as increased greenhouse gases (seven experts), reduced snowfall (six experts), forest fires and melting polar ice caps (one expert), change of rainfall pattern (four experts), late-spring frost (four experts), increased heavy hail (four experts), increased floods (three experts), drought (three experts) and reduced water flow in rivers and springs (two experts). For example, an expert pointed out that "*In May 2017, due to heavy hail, 1000 hectares of strawberry farms in Sanandaj, Marivan and Divandarreh cities were severely damaged*" or another expert believed that "*In the past, we did not have a late-frost event in spring, but in recent years, this phenomenon has increased, which leads to the loss of strawberry fruits*".

3.3.3. Impacts of Climate Change

From the participants' viewpoint, climate change impacts can be divided into physiological, economic, social, natural, and environmental factors (Figure 4). Both groups of farmers and experts linked climate change impacts with agricultural production decline and livelihood loss such that reduction in strawberry yield with 27 (about 44% of all respondents), reduction in job opportunities with 25 (about 40% of all respondents), increasing poverty and hardening of livelihoods with 23 (about 37% of all respondents) and migration with 21 frequencies (about 34% of all respondents) were the most critical impacts of climate change in the study area (Figure 4). For example, one strawberry grower acknowledged that "*The occurrence of droughts and frosts in recent years has severely damaged strawberry yields and led to declining incomes. This has caused many strawberry growers, particularly rural youth, to migrate to cities for finding better jobs and earning more income. Since there are no suitable jobs for them in the city, they are forced to employ in groveling jobs such as fortune-telling or street peddling, which in turn can lead to more social problems*". An expert believed that "*High temperature* *will stress the strawberry plants and cause a diminished strawberry fruit size. Water shortage will also result in small strawberries, and as smaller strawberries take longer to pick, production costs are rising along with high temperature which means lower returns for farmers and in most cases, the price increase for consumers*". In line with these findings, [51] examined the relationship between the average annual temperature and the yield of strawberry in Kurdistan province during the years 1381 to 1395. The findings of this study showed that the sudden increase and decrease in temperature during the strawberry growing season severely affected the performance of this product. Additionally, [34] reported a decline in the crop yield as the top climate change impact in Ethiopia. In addition, [52] identified increased crop failure, migration, and adverse human development effects as the major impacts of climate change in Malawi. As shown in Figure 4, other climate change impacts emphasized by strawberry growers and experts were increasing the perishability of strawberry fruit and reducing surface and groundwater resources. In this regard, the participants believed that given an increase in temperature in the region, the time interval between strawberry harvest and its corruption decreased because the heat intensifies the perishability of strawberry fruit. Impacts of climate change on the perishability of agricultural products were emphasized by [53], who indicated that the quality of fresh fruit and vegetable crops could be directly and indirectly affected by high temperatures and exposure to elevated levels of carbon dioxide and ozone. In addition, two strawberry growers pointed to social problems. For instance, a strawberry grower gave evidence that "*I know many young people from relatives and friends who have migrated from rural to the city due to the drought, and because they did not find a suitable job there, they have faced problems such as poverty, addiction, prostitution, and so on*". Experts have also highlighted some natural and environmental impacts of climate change, such as the overuse of synthetic fertilizers and pesticides (15 experts), increased dust (7 experts), improper use of wastewater (five experts), and unauthorized well drilling (4 experts). For instance, one expert emphasized that: "*Farmers have heard that under water deficit stress, the high potassium content of soil can partially compensate the stress. Therefore, they use potassium fertilizer indiscriminately under drought. However, they do not know that excessive consumption of potassium fertilizer is as harmful as overuse of nitrate fertilizers, while reducing the plant's resistance to pests and some diseases*". Another expert believed that "*Drought may cause the groundwater level to be drawn down. As a result, farmers are trying to deepen their wells or dig new ones*".

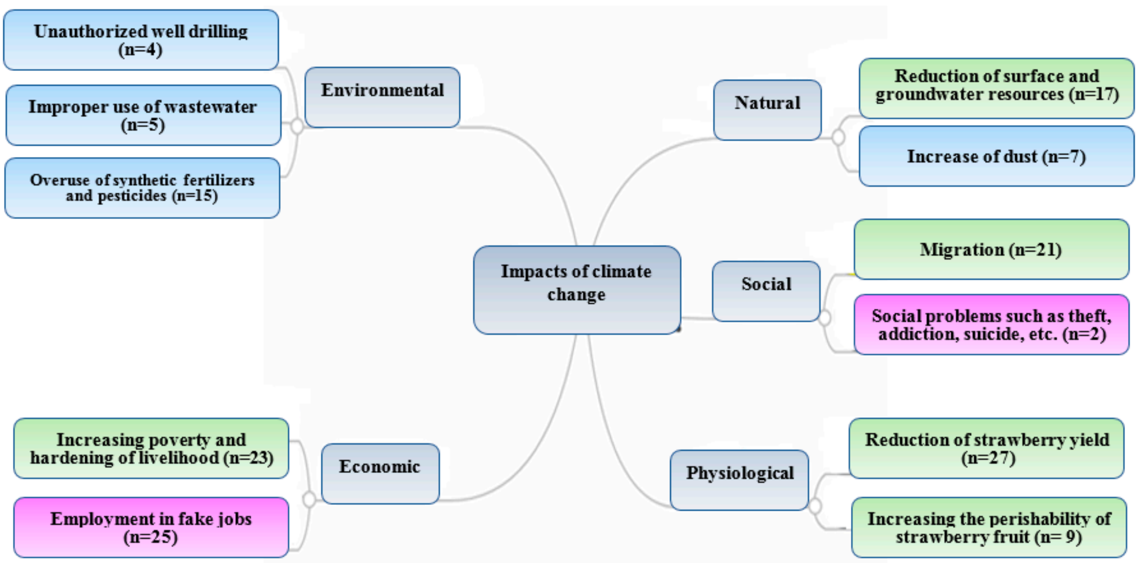

Figure 4. Impacts of climate change from the viewpoint of strawberry growers and experts (Findings from strawberry growers are shown in purple, experts in blue and common results in green). Dark blue shows the various main dimensions of the community that have been impacted by climate change.

3.4. Practical Strategies for Mitigation of Climate Change Impacts

Table 3 shows used strategies for mitigating climate change impacts on the strawberry farms; however, some of these strategies are not widely applied in the region due to some problems and challenges. Using axial coding, these strategies were divided into four categories, including technical–agricultural, water conservation, farm smartening, and institutional adaptation strategies. The most important technical–agricultural strategies included adopting resistant varieties according to the climatic conditions of the region with 29 (about 47% of all respondents), proper use of fertilizers with 26 (about 42% of all respondents), and crop diversification with 10 (about 16% of all respondents) frequencies. Regarding the use of resistant strawberry cultivars, the participants believed that the best strawberry cultivar for cultivation in Kurdistan province is "*Queen Elizabeth*". "*Queen Elizabeth cultivar is well adapted to the climatic conditions of Kurdistan. It has higher flowering and yield*". The use of resistant varieties for adaptation to climate change is consistent with the results of [34,54] in Ghana and Ethiopia. Since strawberry is a climate-sensitive crop, crop diversity is considered by strawberry growers as another valuable strategy for adaptation and an ex ante measure to tackle the probable shock to income as a result of the loss of strawberry crop under climate change conditions, similar to the findings of [55], who found crop diversification as a potential climate change adaptation strategy under different climate scenarios in Bangladesh. The proper use of fertilizers was another adaptation strategy used in the study area. This finding is in accordance with the results of [56]. Planning for strawberry feeding is mainly influenced by soil texture, PH, and soil organic matter content. Indeed, the first step for the proper nutrition of the strawberry bush is soil testing. However, participants believed that with attention to the general condition of the soil in the study area, fertilizers containing calcium, phosphorus, magnesium, manganese, molybdenum, barium, iron, micronutrients, and amino acids could be used. While the lack of any of these substances causes diseases and problems for the crop, particularly under climate change, the excessive use of these fertilizers also leads to unfavorable taste and deformation of strawberry fruits. This finding is congruent with the research by [57].

The most common strategy used by strawberry growers for water conservation under climate change was applying irrigation systems under pressure, such as drip irrigation on the strawberry farms (n = 16). Strawberry bushes have low a tolerance to drought stress and waterlogging conditions due to their shallow root system. Therefore, strawberry irrigation management is essential, so with optimal irrigation management, a significant increase in yield will occur. The best irrigation system for strawberry cultivation is drip irrigation, which, in addition to having more efficiency than furrow and rain irrigation, also prevents the development of many diseases and weeds [57]. In this regard, government assistance and providing subsidies to equip farms with pressurized irrigation systems are among the reasons that have led to the expansion of the use of these irrigation systems as one of the adaptation strategies among strawberry farmers in the study area [58].

Farm-smartening strategies mentioned by experts and strawberry growers included learning scientific principles of planting, holding, and harvesting strawberry (n = 15 or about 24% of all respondents), soil testing to determine current soil fertility and necessary elements for planting strawberry (n = 5 or about 8% of all respondents), and increasing mechanization on the farm (n = 3 or about 5% of all respondents). For example, one strawberry grower stated, "*I not only attend all the extension classes about strawberry cultivation, but I also try to use as much as possible the scientific opinions of experts in the stages of planting, holding and harvesting strawberry*". This finding is in line with the results of [59], who introduced collaborative science and learning as tools for climate change adaptation and resilience of a small community of rural coastal U.S. residents. Moreover, knowing the amount of nutrients and soil fertility as well as identifying nutrient deficiencies are essential factors in sustainable agriculture. The evaluation and fertility of the soil, selection of appropriate cultivation, and balanced consumption of chemical and animal fertilizers lead to success in the optimal production of agricultural products under climate change [60]. In this regard, an expert specified that "*Farmers, especially in recent years, use soil tests to* *determine the amount of nutrients that can be used by plants in the soil. Soil testing is a fast, low-cost, and accurate method, and if random sampling is done, appropriate fertilizers can be recommended to farmers. This not only increases crop yields and reduces environmental pollution but also reduces production costs*".

Table 3. Climate change mitigation strategies.

Category	Strategy †	Frequency
Technical-agricultural strategies	FE: Adoption of resistant strawberry varieties according to climatic conditions of the region	29
	FE: Proper use of fertilizers	26
	FE: Crop diversification	10
	FE: Cultivate strawberry crop under plastic tunnel	8
	F: Greenhouse cultivation	6
	E: Pre-cooling of strawberry products	3
	F: Adjust the planting time of strawberry according to the planted cultivar	2
	F: Cultivation of strawberry crop under orchard trees	1
Water conservation strategies	FE: Applying irrigation systems under pressure such as drip irrigation	16
	F: Construction of water storage tank and pool	3
	F: Purchasing water for farm irrigation	2
	F: Construction of dam	2
	F: Use the Kariz (Qanat) †† to supply water to the farm	1
Farm smartening strategies	FE: Learning scientific principles of planting, holding and harvesting strawberry	15
	FE: Testing soil elements for planting strawberry	5
	FE: Increasing mechanization on the farm	3
Infrastructural-institutional adaptation	F: Storing the product in a cold storage warehouse	27
	E: Establishment of strawberry cooperatives	5
	FE: Strawberry crop insurance	4
	E: Holding strawberry festival	4
	F: Paying more attention to weather announcements and forecasts	4
	F: Proper packaging of strawberry products	3
	F: Processing of strawberry crop	2
	F: Donating clergy and farmers to each other	1

† 'F', 'E', and 'FE' stand for 'farmers', 'experts', and 'farmers and experts' perceptions, respectively. †† A system for transporting water from an aquifer or water well to the surface, through an underground aqueduct.

In addition, several infrastructural–institutional adaptation strategies were emphasized by the study participants, the most important of which were storing strawberry crops in a cold storage warehouse with 27 (about 44% of all respondents), the establishment of strawberry cooperatives with five (about 8% of all respondents), and strawberry crop insurance with four frequencies (about 6% of all respondents) (Table 3). For example, one of the managers in the Agriculture organization stated "*We have established about 40 cold storage warehouses using pre-cooling technology by means of government funds so that some strawberry growers are applying this capacity and cooling their product to prevent corruption until shipping to the market*". Regarding the establishment of strawberry cooperatives, until about three years ago, two strawberry farmers' cooperatives named *Zagros* and *Sar Huyeh* were active in the region. These cooperatives were closed due to the low capital of cooperative members and lack of government support. These cooperatives had presented several services to the members, such as precooling of the strawberry crop, packaging, marketing, and holding strawberry festivals in the area. Currently, the strawberry growers' club is active in the province, which is supported by the government and its secretary is the governor, and it has branches in all the cities of the province. This club helps carry out strawberry-related projects and holds provincial festivals related to this product. This cooperative also already delivered a number of pre-cooling devices to strawberry growers in order to increase the duration of strawberry storage and reduce the temperature of this product from 35 degrees above zero to 4 degrees at the time of harvesting [58].

3.5. Constraints of CSA Implementation in the Strawberry Farms

Table 4 indicates the constraints of developing CSA in the strawberry farms. According to this table, constraints to the development of CSA can be divided into eight categories, including economic, infrastructural, support, attitude, marketing, knowledge and professional, farm management, and organizational constraints. Poverty was the most critical economic constraint that was mentioned by both groups of strawberry growers and experts (n = 38 or about 61% of all respondents) as an obstacle to the development of CSA on the strawberry farms. Poverty and its prevalence are the most important challenges of rural communities in Iran, which is due to the failure of rural development programs in the country [61]. Many interviewees acknowledged that they are well aware of the benefits of using different strategies to deal with the consequences of climatic stressors, such as drought. However, many of these strategies, such as the use of new cultivars, drip irrigation, plastic tunnels, building greenhouse and mechanization of the farms, require significant financial capital that most strawberry growers cannot afford. In this regard, an expert also assigned that "The daily increase in the price of the equipment needed for harvesting and packaging the product, including baskets and cartoons, has caused that the income from strawberry cultivation does not cover its expenses". This finding is consistent with the results of [62,63], who found that one of the most critical obstacles to farmers' adaptation to drought in Iran is poverty and financial inability. High labor cost was another economic constraint mentioned by the respondents. Strawberry is a product that must be picked by hand and handled very carefully. In addition, in the study area, strawberry cultivation is still traditional, and mechanized cultivation is rarely seen. This increases the labor cost of producing this product. Additionally, the shortage of strawberry-processing industries (n = 23 or about 37% of all respondents) was one of the infrastructural constraints that was mentioned by both experts and the strawberry growers. Strawberry is a product that spoils quickly, and the lack of processing industries and poor rural roads will exacerbate this [64]. One expert estimated that "*About 30 percent of the province's strawberry is wasted annually due to a lack of refrigeration equipment and processing industries. With development of processing industries, strawberry production will have a significant role in the rural economy and creation of new job opportunities*". This expert perceived that the lack of processing industries in the region is resulted from the high price of the strawberry crop, desire to sell the raw crop, the inaccessibility of many rural areas, and the difficulty of transporting the crop, which leads to product spoilage before reaching the destination. As a result, investors are reluctant to invest in processing industries.

Among the support constraints highlighted by both study groups, insufficient financial support of strawberry growers from the government with 22 (about 35% of all respondents) and difficulty in obtaining loans and agricultural bank facilities with 17 frequencies (about 27% of all respondents) were the most important. Strawberry growers need financial resources to adopt CSA strategies, equip their farms with new technologies such as smart irrigation systems, use plastic tunnels, etc. However, some respondents believed that the government does not provide enough financial support in the form of subsidies or loans. Moreover, the conditions for benefiting current loans and credits are also very complicated and challenging, and fewer strawberry growers can receive these facilities. Although some experts believed that farmers in the region are significantly dependent on the government aid and avoid being self-reliant, as shown in other studies such as [65,66], the importance of government financial support to deal with various disasters, such as climate change, is undeniable.

Table 4. Constraints for development of CSA in the strawberry farms.

Category	Challenges †	Frequency
Economic	FE: Farmers' financial weakness	38
	E: Inadequate access to financial capitals to make the farm smartening	11
	E: High labor costs of strawberry farming	6
	F: Lack of savings by farmers due to low income	4
	F: Livelihood vulnerability of strawberry growers	3
Infrastructural	FE: Shortage of strawberry processing industries	23
	F: Absence of strawberry farmers' cooperatives	7
	FE: Small-scale of strawberry farms (less than one hectare)	3
	F: Lack of cold storage and warehouse	2
	F: Disturbance of electricity supply to strawberry fields	2
	F: Problems with the water storage tank	1
	F: Water shortage for the farm	1
Support	FE: Lack of cooperation and financial support from the government for strawberry growers	22
	FE: Difficulty in obtaining loans and agricultural bank facilities by strawberry growers	17
	E: Lack of budgets and credits of organizations	13
	F: Lack of crop insurance support	5
	E: Wrong planning and policy setting of the Ministry of Agriculture towards smartening farms	3
Attitude	FE: Mistrust of strawberry growers in the Agriculture Organization	26
	E: Lack of motivation in strawberry growers	17
	E: Have no confidence to the recommendations of agriculture organization regarding CSA	1
Marketing	FE: Difficulties in transporting strawberry crops to the market	31
	FE: Lack of strawberry crop exports	24
	FE: Improper packaging of strawberry crop	22
	FE: Presence of intermediaries and brokers	18
	E: Problems for strawberry storage and refrigeration	18
	F: Improper sales and marketing of strawberry products	9
	E: Lack of guaranteed purchase of strawberry crop	5
	F: Improper roads connecting farms to the market	5
	E: Low quality of strawberry crop	2
	F: Short selling strawberry crop due to poor living conditions	1

Table 4. *Cont.*

Category	Challenges †	Frequency
Knowledge and professional	E: Traditional and unscientific thinking of strawberry growers and their fatalism	16
	E: Poor training of strawberry growers	10
	E: Low education level of strawberry growers	4
	E: Lack of strawberry growers' technical knowledge about smartening strawberry farms	4
	E: Lack of attention to weather announcements among strawberry growers	2
	F: Lack of experts' attention to the strawberry growers' opinions and conditions	2
	E: Little knowledge in the field of planting, holding, harvesting and marketing among strawberry growers	1
	E: Language barriers	1
Organizational	E: Inadequate attention of the Ministry of Agriculture to problems and challenges of strawberry growers	12
	FE: Poor climate forecast	12
	E: Lack of manpower in the agriculture organization	9
	E: Low cooperation of the Meteorological deputy with strawberry growers	8
	E: Lack of agricultural meteorological stations	5
	E: Wrong planning and policy setting of the Ministry of Agriculture	4
	F: Low information of agricultural experts regarding CSA	3
	F: Lack of transparency and strict supervision of the Agriculture Organization about water consumption in the agricultural sector	2
	F: Unfair distribution of institutional services between strawberry growers	2
	E: Issuing general announcements for the province and not paying attention to geographical differences	2
Farm management	FE: Lack of mechanization on the strawberry farms	29
	E: Traditional cultivation of strawberry crop	26
	FE: Outbreak of pests and diseases	9
	E: Use of untreated wastewater to irrigate farms	7
	E: Cultivation of low resistant varieties	6
	E: Improper use of synthetic fertilizers and pesticides	4
	F: Inadequate access to agro-inputs	3
	E: Low adoption of climate smart technologies on the farm	2
	F: The high cost of hiring a farm worker	2
	F: Lack of greenhouse cultivation facilities	2
	F: Lack of suitable strawberry seedlings	1

† 'F', 'E', and 'FE' stand for 'farmers', 'experts', and 'farmers and experts' perceptions, respectively.

The mistrust of strawberry growers in the Agriculture organization (mentioned by 26 strawberry growers and experts) and lack of motivation in them (mentioned by 17 experts) were among the most important attitude constraints for the development of CSA on the strawberry farms. Both experts and strawberry growers believed that giving empty promises to farmers and not fulfilling these promises in practice is one of the most important reasons for strawberry growers' distrust of the Agriculture organization and the government. For example, a farmer in the city of Marivan stated "*Last year, the Agriculture* *organization promised that provide us cold storage to store strawberry fruits after harvesting, but this promise was not fulfilled. Many of the promises of the Agriculture organization are similar to this and do not happen in practice*". This finding is consistent with the results of many other studies in Iran (e.g., [67,68]), which have shown that farmers' distrust of the government and agricultural organizations is the cause of the failure of the agricultural and extension program. Difficulties in shipping strawberry crops to the market, a lack of strawberry crop exports, the improper packaging of strawberry crops, and the presence of intermediaries and brokers were the most critical marketing constraints, which are preventive factors for the development of CSA on the strawberry farms. Strawberries are a product that requires exact transportation and proper handling [69]. However, the transportation system of strawberry products in the region is not suitable, and this factor is one of the critical reasons for not exporting this product. However, another important reason for not exporting strawberries is the lack of storage facilities and equipment and the export terminal in the province. Regarding the presence of brokers and intermediaries, one of the strawberry growers stated "*In order to package our products, we have to send strawberry to the center of the province or other provinces. So, we inevitably sell our products to intermediaries and brokers at low prices*". He added: "*Lack of support from the authorities for gardeners and the existence of brokers and intermediaries have caused the strawberry growers in Kurdistan do not receive much profit despite the hard work they do during the year*". He believed that this would make gardeners reluctant to cultivate this crop and would lead to unemployment for this group.

Traditional and unscientific thinking of strawberry growers was one of the knowledge and professional constraints mentioned by 16 experts as a preventive factor for the development of CSA in strawberry farms. In contrast, strawberry growers expressed inadequate attention of the Ministry of Agriculture to problems and challenges of strawberry growers, limited knowledge of agricultural experts about CSA and adaptation strategies as well as their lack of attention and respect for farmers' ideas and conditions as some professional and organizational barriers to implementing CSA in the strawberry farms. The negative influence of traditionalism on the adoption of innovations or their early adoption has been emphasized in various studies. For example, Mahmood et al. [70] found that traditionalism negatively correlates with the farmers' resilience in Pakistan. On the other hand, attention to and respect for the knowledge, skills, beliefs, and conditions of farmers is a prerequisite for the success of any extension program for the development of CSA on the strawberry farms. According to [71], disrespecting farmers and treating them as inferior partners will lead to their reneging to fulfill their commitments and the failure of agricultural programs.

Lack of mechanization on the farms and traditional cultivation of strawberry crops were the most crucial farm management constraints highlighted by research participants. Numerous reasons, including the lack of necessary training to encourage farmers to switch to mechanized cultivation, small farms, and the lack of necessary support in the field of planting, holding and harvesting, have caused most strawberry farms to be managed through traditional methods.

3.6. Drivers of CSA Development

As shown in Table 5, drivers of CSA development from the viewpoint of the participants can be divided into seven categories, including financial support, institutional support and policy making, marketing, farm management, knowledge and professional, infrastructural and attitude, and organizational culture factors. Based on this table, granting credits to strawberry growers by the government (proposed by 24 strawberry growers and experts or about 39% of the all respondents), increasing strawberry growers' income through rural tourism development (proposed by 21 strawberry growers and experts or about 34% of the all respondents), and increasing cooperation between organizations that can provide financial services to strawberry growers or assist them in receiving financial support (proposed by 6 experts) were three proposed financial drivers of developing CSA in the study area. According to [72], the transition from existing agricultural systems to CSA systems, which is often time-consuming in terms of profitability and productivity, requires financial resources and spending money. However, strawberry growers often do not have the initial capital to use many of the CSA strategies on the farm. In this regard, taking advantage of a range of available financing sources, providing financial incentives to support the adoption of CSA strategies by using various approaches, such as facilitating the conditions for receiving financial facilities and providing joint-liability group lending, were proposed. Moreover, according to [73], rural tourism has a high potential to stimulate local economic growth and social change because of its complementarity with other economic activities, contribution to GDP, and job creation. In this regard, villages of Kurdistan province, with beautiful and pristine natural landscapes, historical and cultural monuments, biodiversity, forest cover, and vast pastures, have a high capacity for the development of rural tourism [74]. One of the experts claimed that "*Kurdistan could meet all its employment needs by strengthening the tourism sector, including rural and agro-tourism*". This finding is consistent with [75,76], who found that job diversification and provision of secondary income are efficient strategies for farmers' adaptation to climate change.

The most critical institutional support and policy-making drivers were developing more efficient programs and policies by the government to facilitate agricultural development (proposed by 21 experts) and supporting the implementation of pressurized irrigation systems on the strawberry farms (proposed by 13 experts). It implies that facilitation of agricultural development through technical, infrastructural, social, and economic factors, providing subsidies to mechanize farms, and development of pressurized irrigation systems are essential for implementation of CSA. Since private institutions and NGOs are often absent to support the agricultural sector in Iran, the government is most expected to provide these supports.

The most crucial marketing drivers were the facilitation of product shipping and improving the physical condition of roads (proposed by 13 strawberry growers and experts), and guaranteed purchase of strawberry crops by the government (proposed by 8 strawberry growers). One strawberry grower stated, "*Guaranteed purchase of the strawberry product by the government can drive brokers and intermediaries out of the strawberry market*". Additionally, an expert assigned that "*By improving road conditions and providing proper vehicles, the quality of harvested strawberry can be better preserved*". Every year, the government has a guaranteed purchase policy for products such as wheat, rice, barley, corn, beets, potatoes, onions, beans, cotton, and oilseeds in order to support the production of essential agricultural products, balance the production system, prevent waste of agricultural products and losses of farmers. Considering this, a guaranteed purchase policy can also be considered for strawberries as a strategic product of Kurdistan province. It was confirmed by [77,78].

The most critical farm management drivers were using appropriate varieties of strawberry for each region (proposed by 29 strawberry growers and experts), the development of strawberry cultivation under plastic tunnels (proposed by 12 strawberry growers and experts), establishment of greenhouse (proposed by 9 strawberry growers) and provide adequate and timely access to farm inputs (proposed by 7 strawberry growers and experts). The adoption of resistant crop varieties is one of the most important adaptation strategies in different parts of the world, which has been mentioned in most studies (e.g., [22,79–81]). Therefore, the research organization must introduce resistant and suitable strawberry varieties, taking into account the climate change situation, and, with the help of the Agriculture organization, provide these varieties for the strawberry growers. In addition, agricultural agents must encourage farmers to use resistant cultivars by carrying out various extension activities. Additionally, providing vocational training to resource-rich strawberry growers regarding cultivation under plastic tunnels or building greenhouses and encouraging them to use these strategies will be a worthy driver for CSA development in the strawberry farms.

The most proposed infrastructure drivers were increasing farmers' access to CSA technologies (proposed by 22 experts) and the development of strawberry processing industries (proposed by 20 strawberry growers and experts). The economy of Kurdistan province is significantly reliant on the agricultural sector, and this sector can play a crucial role in the province's employment. Therefore, it is imperative to provide the necessary infrastructure for agricultural development. Products such as strawberries, which have a large share of the province's agricultural market and consequently the country, need to take the necessary measures to develop and increase profits from this product and maximize productivity. Kurdistan produces about 80 percent of the country's strawberry crops but does not yet have any processing industry for this product [57].

Table 5. Drivers of CSA development in the strawberry farms.

Category	Drivers †	Frequency
Financial supports	FE: Granting credits to strawberry growers by government	24
	FE: Increasing strawberry growers' income through rural tourism development	21
	E: Increasing cooperation between organizations that can provide financial services to strawberry growers or assist them in receiving financial services such as banks and agriculture organizations	6
Institutional supports and policy making	E: Developing more efficient programs and policies to improve agricultural situation	21
	E: Facilitating adoption of pressurized irrigation systems	13
	E: Supervision of responsible organizations for available water resources	5
	E: Collaboration with farmers to test farm soil	5
	E: Provide timely access to weather information	3
	F: Development of strawberry crop insurance	3
	F: Reducing dependence of strawberry growers on Agriculture organization and the government	1
Marketing	FE: Facilitation of product transportation and improvement of the physical condition of roads	13
	F: Guaranteed purchase of strawberry crop by government	8
	F: Suitable packaging of strawberry crop	7
	FE: Facilitating strawberry exportation	7
	FE: Eliminating or reducing the power of intermediaries and brokers	3
	F: Creating seasonal strawberry markets	2
Farm management	FE: Using appropriate varieties for each region	29
	FE: Development of strawberry cultivation under plastic tunnels	12
	F: Establishment of greenhouse	9
	FE: Supply of farm inputs for strawberry growers by Agriculture organization	7
	F: Proper use of synthetic fertilizers and pesticides in the strawberry farms	6
	FE: Land integration	6
	F: Application of new methods for farm irrigation	6
	F: Preventing unauthorized exploitation of water resources	3
	F: Using livestock manure in the farm	3
	FE: Using fresh or treated waste water resources	2
	F: Adjusting the planting time of strawberry according to the climatic conditions of the region	1

Table 5. *Cont.*

Category	Drivers †	Frequency
Knowledge and professional	FE: Educating and promoting CSA strategies to strawberry growers	14
	E: Improving agricultural extension services	13
	E: Paying more attention to indigenous knowledge	9
	E: Gaining knowledge in the field of principled control of pests, diseases and weeds	8
	F: Holding training classes about the successful global experiences in relation to CSA by the Agricultural organization and agricultural agents	7
	E: Training agricultural experts about CSA practices and technologies	3
	E: Gaining knowledge about the appropriate time to cultivate strawberry	2
	E: Acquiring awareness about the importance of farm fallowing	2
	E: Utilizing experts' knowledge about the principled cultivation on the farm	2
	E: Awareness of the principles of organic agriculture and attention to its development	1
Infrastructure	E: Increasing farmers' access to CSA technologies	22
	FE: Development of strawberry processing industries	20
	FE: Creating cold warehouse for storage strawberry crop	17
	E: Development of greenhouse cultivation of strawberry	10
	E: Development and investment in mechanization	8
	F: Establishment of strawberry growers' cooperative	8
	F: Construction of water storage pool	3
	E: Establishment of agricultural meteorological stations	3
	F: Supply of fuel for agricultural implements and electric motors	2
Attitude and organizational culture drivers	FE: Changing attitude and motivate of strawberry growers for moving towards CSA	13
	F: Friendly behavior of agricultural experts with strawberry growers	1
	F: Observance of justice by the government among farmers in terms of distribution of agricultural inputs and facilities	1

† 'F', 'E', and 'FE' stand for 'farmers', 'experts', and 'farmers and experts' perceptions, respectively.

Finally, the most crucial attitude and organizational culture driver was changing attitudes and motivating strawberry growers for moving toward CSA (proposed by 13 strawberry growers and experts). Applying CSA strategies in the strawberry farms requires changing the beliefs and attitudes of strawberry growers toward this farming system and motivating them to apply its strategies in practice. Making such a change in the beliefs, attitude, and motivation of strawberry growers is within the scope of agricultural extension responsibilities. In most developing countries, the scope of agricultural extension purposes is different, from serving as a mediation between research centers and farmers, to functioning as a facilitator for farmers' empowerment to address complex problems. However, agricultural extension systems of most developing countries are fragile and unsystematic, characterized by short-term projects, lack of coordination between providers, limited financial and human resources, and advisers who lack the knowledge and skills to address the new demands [82,83].

4. Limitations of the Research

The present study focused on Kurdistan province in Iran. Additionally, in this study, case study was used as one of the qualitative research methods to investigate the research topic. As we know, "the goal of most qualitative studies is not to generalize but rather to provide a rich, contextualized understanding of some aspect of human experience through the intensive study of particular cases" [84]. Therefore, one of the limitations of the current research is that the findings of this research are directly applicable to strawberry growers in the study area, and this is difficult to generalize the findings to other groups, products and regions. More and wider-ranging research is, therefore, recommended to obtain more generalizable results. In addition, the current study was conducted during the COVID-19 epidemic, which made data collection somewhat difficult. Although we, as the researchers, tried to obtain the most accurate and in-depth data about the research subject, due to the non-normality of the conditions, there is a possibility that some aspects were not sufficiently taken into account.

5. Conclusions and Policy Implications

In recent years, CSA has been introduced as an approach to managing agricultural systems and their effective response to climate change impacts. However, any effort to develop CSA requires awareness of its strategies, constraints, and drivers. So, this qualitative case study was conducted to explore the causes, evidence and impacts of climate change, strategies used for the mitigation of climate change impacts on the strawberry farms, and also constraints and drivers for the implementation of CSA in practice from the viewpoint of strawberry growers and agricultural experts in Kurdistan province, Western Iran.

Findings indicated that the causes of climate change could be divided into anthropogenic and natural forces. Farmers looked at the natural causes of climate change with a fatalism viewpoint and considered it the will of God, while experts looked at the issue with a scientific viewpoint and provided scientific causes for it. Additionally, they believed that climate change had negative impacts in the study area, such as physiological, economic, social, natural and environmental impacts.

For adaptation to climate change and mitigation of its impacts, strawberry growers have adopted several strategies. These strategies were classified into four categories, including technical-agricultural, water conservation, farm smartening, and institutional adaptation strategies. In this regard, the adoption of resistant strawberry varieties, proper use of fertilizers, crop diversification, cultivating strawberry crops under plastic tunnels, applying irrigation systems under pressure, learning scientific principles of planting, holding and harvesting strawberry and storing the product in a cold storage warehouse were some of the critical strategies introduced by the interviewees. However, both farmers and experts acknowledged that various constraints prevented the widespread use of these strategies in the study area. Constraints were divided into eight categories, including economic, infrastructural, support, attitude, marketing, knowledge and professional, farm management, and organizational factors. Poverty was the most important economic constraint to use CSA strategies in the strawberry farms. Additionally, the shortage of strawberry processing industries was one of the infrastructural constraints. Additionally, the insufficient financial support of strawberry growers from the government, and difficulty in obtaining loans and agricultural bank facilities have also doubled strawberry farmers' problems for using CSA strategies in the farm. This issue, along with small farms and the lack of necessary training to encourage farmers to switch to mechanized cultivation, has made strawberry cultivation traditional. Difficulties in shipping strawberry crops to the market, lack of strawberry crop exports, improper packaging of strawberry crop, and the presence of intermediaries and brokers were some significant marketing constraints, which prevented the development of CSA on the strawberry farms. Lack of storage facilities and equipment and the export terminal in the province, as well as improper transportation system of the strawberry crops were some of the causes of failure in exporting strawberries. In addition to these constraints, the mistrust of strawberry growers in the Agriculture organization has significantly reduced the motivation of strawberry growers to use CSA on the farm. Another interesting point about impediments of CSA development was the disagreement of strawberry growers and experts on the knowledge and professional constraints. Agricultural experts believed that the traditional and unscientific thinking of strawberry growers, lack of technical knowledge about smartening strawberry farms, lack of attention to weather announcements, and lack of motivation among strawberry growers are major impediments to development. In contrast, strawberry growers referred to restrictions such as lack of experts' attention to the strawberry growers' opinions and conditions, unfair distribution of technical and non-technical support services, and low information of agricultural experts about CSA.

In the next stage of the research, the respondents proposed some drivers which can be used as a basis for policy and decision making to overcome the existing constraints on CSA development. Drivers of CSA development were divided into seven categories, including financial support, institutional support and policy making, marketing, farm management, knowledge and professional, infrastructural and attitude, and organizational culture. Rural tourism development was a proposed financial driver for CSA development in the study area. Adopting some tourist attraction strategies, such as conducting suitable advertisements for agro-tourism by Kurdistan cultural heritage, tourism and handicrafts deputy, organizing and planning activities in the strawberry farms level for tourist's attraction, such as holding strawberry festivals by the strawberry growers' club and Agriculture organization, and also strengthening the friendly behavior of strawberry growers with tourists not only can increase employment opportunities in the region through tourism boom, but can create a secondary source of income. Therefore, it will increase their adaptation capacity and ability to implement on-farm CSA strategies. While strawberry growers often do not have the initial capital to use many of the CSA strategies in the farm, supportive drivers, such as facilitating the conditions for receiving financial facilities, providing joint-liability group lending, providing subsidies by the government to mechanize farms, and adopting pressurized irrigation systems, are some financial incentives to support the implementation of CSA strategies on the strawberry farms. Additionally, the facilitation of product shipping and improving the physical condition of roads, and guaranteed purchase of strawberry crops by the government were some important marketing drivers. In this regard, implementing a guaranteed purchase policy for strawberries as a strategic product of Kurdistan province will raise the province's economy, expel intermediaries and brokers from the strawberry market, prevent the losses of strawberry growers, and increase their motivation to continue strawberry production. For CSA development on strawberry farms, the role of agricultural research institutions and agricultural extension should not be overlooked. Using climate-resistant varieties of strawberry for each region and the development of strawberry cultivation under plastic tunnels were important farm management drivers for CSA development. For this, the research organization can introduce resistant and suitable strawberry varieties, taking into account the climate change situation; the Agriculture organization can provide these varieties; and extension agents can diffuse these varieties between strawberry farmers. In addition, applying CSA strategies in the strawberry farms requires changing the beliefs and attitudes of strawberry growers toward this farming system and motivating them to apply its strategies in practice. Making such a change in the beliefs, attitude, and motivation of strawberry growers to move toward CSA is within the scope of agricultural extension responsibilities. The agricultural organization's empty promises to strawberry growers have created a negative attitude toward this organization and its experts, including agricultural agents. Therefore, the first step to the success of agricultural extension for CSA development is to regain farmers' trust by fulfilling its promises, involving them in the activities, improving the communication power of agricultural agents and strengthening and updating their knowledge of CSA strategies. Additionally, the existence of contradictions and inconsistencies between strawberry farmers and experts requires creating a space for dialogue between different stakeholders in order to focus on effective interventions and extension activities for the utilization of CSA on strawberry farms. Finally, it is necessary to provide the necessary infrastructure in the province. In this regard, one of the fundamental infrastructure drivers is the development of strawberry processing industries in the province. Meanwhile, by taking appropriate measures and carrying out principled planning, strawberries can be produced in different seasons of the year, and by attracting investors to the province and providing them with various incentives, they can set up processing industry factories in order to create employment and improve the livelihoods of farmers in the province.

Overall, the present study provides new knowledge about practical strategies of CSA for the mitigation of climate change impacts on the strawberry farms, constraints of CSA implementation in the strawberry farms and drivers of CSA development. The findings of this study offer some insights to policymakers and planners for making effective decisions about diffusion and implementation of CSA in the farms for the mitigation of climate change impacts. In particular, the drivers of CSA suggested by strawberry growers and experts are quite practical and can be considered a guide for policy making.

Author Contributions: Conceptualization, P.M., G.M. and M.K.; methodology and software, P.M. and M.K.; validation, P.M., G.M. and M.K.; writing—original draft preparation, P.M.; funding acquisition, G.M. and P.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the vice chancellor for research of University of Zanjan, Iran.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The Vice Chancellor for Research of University of Zanjan is sincerely thanked for providing the costs of this research, which is part of a Ph.D. thesis.

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

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