



Research Article

The Economic Impact of Climate Change on the Local Apple

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ABSTRACT

An unavoidable climate change has an impact on agricultural production. This study aims at determining farmers' knowledge concerning climate change and farmers' behavior in apple cultivation, as well as it aims at investigating the impact of climate change on apple productivity, environmental damage, and apple prices. Primary data were collected using structured interviews to farmers of apple. Structural Equation Model (SEM) is employed to analyze the effect of climate change on production, environment and price changes. The results showed farmers possessed knowledge concerning climate change based on information mainly received from television and their perceived experience. Climate change causes the increase of warmer air temperatures, drought, and the need for product facilities, like fertilizers and pesticides. However, it causes the decrease of apple production. Climate change has a significant negative effect on apple productivity and the economic value of apples. The environment also has a negative effect on apple productivity at a lower level of significance. During climate change, apple productivity has a negative effect on apple prices, It means that the higher the apple productivity is, the lower the apple price will be. Hence, climate change caused the impact of a decrease in the economic value of local apple agribusiness in Malang Raya.

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INTRODUCTION

Rapid climate change is currently having far-reaching impacts on the agricultural sector. Climate changes (such as temperature, rainfall, and humidity) can cause a decline in the amount and quality of land, water, and microclimate where horticultural crops are grown (Hutabarat et al., 2012). Apples are an annual fruit plant originating from West Asia with a suitable sub-tropical climate for growing in Malang Raya. Apple cultivates and bears fruit well in highland areas with low temperatures. Malang Raya, East Java, become a good plafe for cultivation and development of apple. The production centers are located in Batu City and Poncokusumo, Kabupaten Malang (Ruminta & Handoko, 2012); apple is one of the superior products specifically for Malang Raya, and it is able to support its tourist areas (Santoso & Sabita, 2011).

The impact of climate change also occurs in changes in farmers' behavior in cultivation. Farmers give efforts to return and use agricultural resources after climate change (Manuel & Fragoso, 2018; Shakhawat et

al., 2019; Xie et al., 2018). Three important elements related to the sustainability of apple cultivation are land ownership, apple productivity, and production costs. Sustainability of apple cultivation occurs if it is supported by policies, utilization of land resources, an increase in apple productivity, combination between both (utilization of land resources and an increase in apple productivity), and replacing chemical pesticides with organic pesticides.

Apple productivity is affected by cultivation techniques, soil fertility, plant pest and disease control, weed control, and climatic conditions (Rumudarainta & Handoko, 2012). The development of apple production has spurred the development of other agribusiness, like suppliers of agro-input, transportation services, and processing industries. The development has also enhanced a particular attraction for the development of the agro-tourism industry. Apple farming, which was originally cultivated in the yard, later expanded to dry land which was previously planted with vegetables with increasingly intensive garden maintenance. The number of apple plants reached 1,974,366 trees with a production of 842,799 quintals (Badan Pusat Statistik Kota Batu, 2018). An increase in apple commodity agribusiness activities towards the intensification of orchard management has unknowingly resulted in environmental changes of cultivation around apple plants continuously. Intensification of apple cultivation follows the changes desired by farmers to get the maximum profit.

Relawati et al. (2018) employ a structure-conduct-performance (SCP) analysis for the apple market in Malang, and they found that the structure of the apple market is an oligopoly. The finding indicates the party with the strongest oligopoly power is the wholesaler of apple packers. Consistent with the market structure, market behavior shows that wholesaler of apple packers is the most formidable party in the bargaining position to determine the apple price. The structure and behavior of the market consistently affect market performance, where the strongest oligopolist gets the most profit.

The results of previous research on climate change showed that farmers felt the uncertainty of the weather, the increase in air temperature, and the scarcity of water during the dry season (Relawati et al., 2021) and reduced crop production (Habtemariam et al., 2017; Zhang et al., 2017). Therefore, farmers must adapt to climate change to maintain crop production and food security (Ali & Erenstein, 2017; Ferreira et al., 2020; Relawati et al., 2021).

Many researches on Malang apples investigate the business and economic aspects. The marketing strategy for apples from Malang shows that the strengths of apples from Malang are fresher, healthier and relatively cheaper than imported apples (Relawati et al., 2019). The findings showed that local apple prices are affected by its cultivar (type) and its freshness (Relawati et al., 2017). More specifically, research analyzing climate change and apple production found that apple production and farm income decreased (Santoso & Sabita, 2011).

The Structural Equation Model (SEM) with the WarpPLS approach was utilized to analyze the factors and economic impacts of climate change. The variable of climate change has formative indicators including temperature, rainfall, and humidity. This variable affects the variable of apple productivity, environmental changes and economic changes. The variable of apple productivity has reflective indicators, including the number of apple trees, production, and productivity per tree. This variable affects the variable of economic change. The variable of environmental change has reflective indicators, including a decrease in soil organic matter, an increase in pests and diseases, an increase in land use change, and the use of inputs. This variable affects the variable of economic change. The variable of economic change as the dependent variable has a reflective indicator, namely the price of apples. Concurrently, the theoretical relationship between variables is depicted in Figure 1.

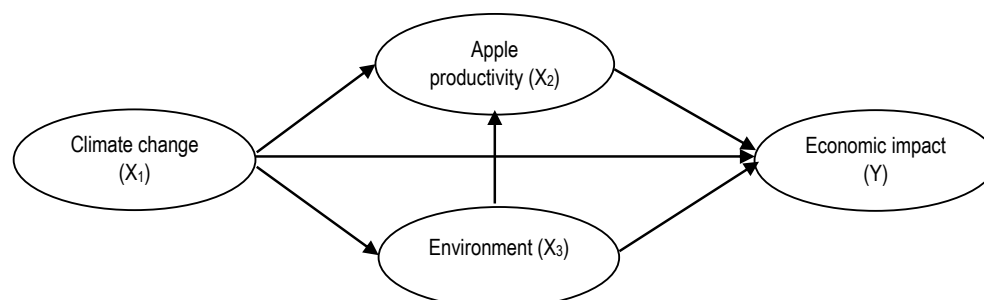


Figure 1. Theoretical Model of Economic Impacts Due to Climate Change

Various previous research concerning local apples in Malang have not investigated the economic impact of climate change on apple production, even though this information is critically significant in determining the policies of apple agribusiness development. The novelty of this study is to examine the economic impact of climate change on apple agribusiness. The research objectives in this study are to find out: 1) farmers' knowledge concerning climate change and behavior in apple cultivation; 2) the impact of climate change on apple productivity, environmental damage, and apple prices.

METHOD

This study was conducted in two sub-districts where apple production is located in Malang Raya. They are Poncokusumo, Kabupaten Malang Regency and Bumiaji, Batu City. Both places are apple cultivation centers in Malang Raya. Primary data were collected utilizing structured interviews to apple farmers by distributing a questionnaire. The number of samples of apple farmers is 45 people, each 25 from Bumiaji and 20 from Poncokusumo.

Primary data were measured utilizing ratios and ordinal scales. The ratio scale is utilized to measure indicators of changes in apple prices, climate change, and apple productivity. The ordinal scale is utilized to measure climate change based on the experience felt by farmers on a number of indicators. Those indicators are reduction in nutrients, increase in pests and diseases, changes in land use, and use of fertilizers (Table 1).

The first objective is about farmers' knowledge concerning climate change and farmers' behavior in apple cultivation, in which both were analyzed with quantitative and qualitative descriptions. The second objective is the impact of climate change on apple productivity, environmental damage, and apple prices, in which it was analyzed utilizing the Structural Equation Model (SEM) method. The SEM analysis software utilized is WarpPLS. The advantage of WarpPLS is that it can be used on small samples (30-100 samples). It is because there is re-sampling (Solimun et al., 2017). In detail, the indicators and measurement scales employed in the SEM model are presented in Table 1.

Table 1. The Latent Variables, Indicators, and Measurement

No	Latent Variables	Indicators	Measurement
1.	Economic impact (Y)	Y Price of Apple	ratio scale
2.	Climate change (X ₁)	X _{1.1.} Average temperature	°C
		X _{1.2.} Rainfall	Mm
		X _{1.3.} Air humidity	%
3	Apple productivity (X ₂)	X _{2.1.} Number of trees	plants
		X _{2.2.} Production	tons
		X _{2.3.} Productivity	Tons /tree
4	Environmental change (X ₃)	X _{3.1.} Organic decline	ordinal (1-5)
		X _{3.2.} Increase in pest disease	ordinal (1-5)
		X _{3.3.} Increase in land use change	ordinal (1-5)
		X _{3.4.} The use of fertilizer	ordinal (1-5)

The SEM analysis model for the second research objective follows the framework of the empirical model in Figure 1. Explanation of the mathematical formulation of each model's inner relationship is manifested in six equations. The equations of the SEM model are written in equations (1) to (6)

$$\begin{aligned}
 X_2 &= \beta_{01} + \beta_1 X_1 + \epsilon_1 && \dots\dots\dots (1) \\
 X_3 &= \beta_{02} + \beta_2 X_1 + \epsilon_2 && \dots\dots\dots (2) \\
 X_2 &= \beta_{03} + \beta_3 X_3 + \epsilon_3 && \dots\dots\dots (1) \\
 Y &= \beta_{04} + \beta_4 X_1 + \epsilon_4 && \dots\dots\dots (3) \\
 Y &= \beta_{05} + \beta_5 X_2 + \epsilon_5 && \dots\dots\dots (4) \\
 Y &= \beta_{06} + \beta_6 X_3 + \epsilon_6 && \dots\dots\dots (5)
 \end{aligned}$$

where:

- X₁ = Climate change
- X₂ = Apple productivity
- X₃ = Environmental change
- Y = Economic impact (price)

$\beta_{01} - \beta_{05}$ = Path coefficient
 $\epsilon_1 - \epsilon_5$ = Error of estimation

RESULTS AND DISCUSSION

Farmers' Knowledge Concerning Climate Change and Farmers' Behavior in Apple Cultivation

Apple farming was originally cultivated in the yard. It then expanded to the dry land which was previously planted with vegetables with increasingly intensive garden maintenance. In the fourth quarter of 2018, the number of apple plants reached 952,863 trees with production reaching 145,237 quintals (Badan Pusat Statistik Kota Batu, 2018).

Apple productivity per tree (Figure 2) is reflected in the number of productive trees and the level of apple production. In the last ten years (2009 to 2018), the average of apples productivity has reached 10.9 quintals/tree. The number of productive trees is 2,097,670 trees and the production level is 196,507.4 quintals (Badan Pusat Statistik Kota Batu, 2018). These three parameters have a tendency to decrease. Significant factors causing this decline are environmental and climate change (Bernetti et al., 2012; Relawati et al., 2021; Santoso & Sabita, 2011).

Figure 4. empirically shows that the contribution of environmental change is negative of 0.3, meanwhile for climate change it is negative of 0.43. It means that extreme environmental and climate changes are inversely related to productivity, number of productive trees and production levels. The increase in extreme environmental and climate changes in an area causes productivity, the number of productive trees, the level of apple production to decrease, and vice versa. It is in line with research conducted by (Aryal et al., 2018; Budiastuti, 2010; Chandio et al., 2020; Santoso & Sabita, 2011; Shakhawat et al., 2019) stating that environmental changes (such as a decrease in soil organic matter, an increase in pests and diseases, an increase in land conversion, and the use of inputs) affect apple productivity. Likewise, what happens to climate change (such as temperature, rainfall, and humidity) significantly affects apple productivity.

An increase in temperature above the optimum temperature for apple production can cause leveling off. Concurrently, the increase in rainfall causes the flowering process of apples to be disrupted and young apples to fall, thereby reducing apple production. Besides, the increase in rainfall causes an increase in air humidity. Therefore, it has the potential for the development of pests and diseases threatening the production of apple plants. In addition to changes in production, climate change also has an impact on the use of production inputs such as fertilizers and pesticides which increase significantly. It is confirmed by the findings of (Habtemariam et al., 2017; Zhang et al., 2017) stating that climate change has an impact on reducing crop production.

Climate change (such as air temperature and rainfall) occurs gradually. Climate change has an impact on the apple farming environment. Research facts (Figure 3) show that some farmers have knowledge about climate change but some do not. A total of 38 apple farmers (82.2%) has knowledge concerning climate change, and 7 people (17.8%) do not. The percentage of farmers having knowledge concerning climate change is the majority because it is more than 75%.

The results of the study support the previous findings although in a different way of measurement. Strawberry farmers have a high intensity of knowledge concerning climate change, which is 3.81 out of a maximum score of 5 (Surya Negara et al., 2015). Likewise, rice farmers in Kedah - Malaysia, the majority of farmers have an understanding of climate change from temperature, rainfall, drought, and flooding (Akhtar et al., 2018).

Apple farmers' knowledge concerning climate change is obtained from various sources (Figure 3). A total of 28 farmers (62.2%) obtained knowledge concerning climate change from television, and the remaining 17 others (37.8%) from non-television (information from villages and/or mass media). The findings of this study indicate television is still a source of information for knowledge obtained by farmers. Apple farmers who are mostly 45 to 55 years old still have the habit of watching television in their spare time and resting at home. Although the culture of watching television programs has begun to be abandoned by millennials by switching to online media and social media, it seems that this has not yet become entrenched in apple farmers when the study was conducted. These results confirm the findings of (Lesmana, 2013) stating that 80% of farmers in the villages (research site) use television to obtain agricultural information although there are different research findings stating that farmers do not use information technology and mass media including television, but rather because of limited signal (Harahap, 2016).

Rainfall and air temperature are elements experience changes. A total of 36 apple farmers (80%) felt an increase in rainfall, and as many as 9 farmers (20%) felt climate change from an increase in air temperature. The number of respondents experiencing changes to the morphology of the apple plant was 41 people (91.1%) and 4 people (8.9%) did not feel that they had changed. Changes in the intensity of pest and disease attacks on apples were felt by the majority of farmers, namely 38 people (84.4%), and 7 people (15.6%) said that there was no change in the intensity of pest and disease attacks.

The scientific explanation of the various phenomena experienced or felt by farmers is that the hitergraft was higher between 2011-2030 compared to 1999-2010 so that the air temperature was hotter and drier (Ruminta, 2015). It is a fact that farmers do feel the air temperature is hotter and drier although they don't always know or check the air temperature. Climate change causes the accumulation of greenhouse gases, resulting in changes in rainfall, temperature and carbon dioxide fertilization, and it has an impact on agriculture (Karimi et al., 2018).

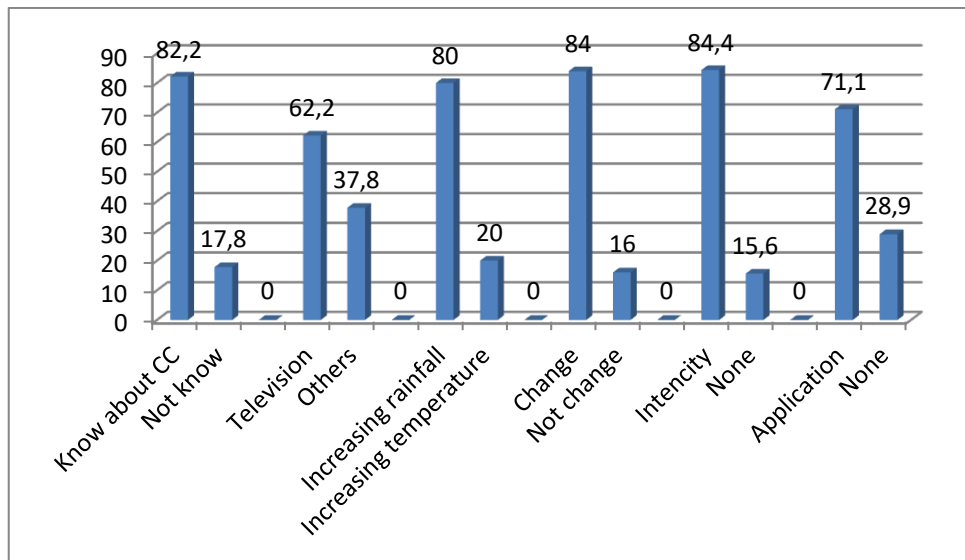


Figure 3. Farmers' Knowledge and Behavior

Climate change has an impact on farmers' behavior in apple cultivation. Due to the increase of pests and diseases attack during the climate change period, farmers carry out intensive maintenance on farming. A total of 32 people (71.1%) sprayed growth regulators (ZPT), fungicides and insecticides for apple plants. Spraying the drug is carried out so that plants grow rapidly and avoid pests and diseases.

Apple farmers taking care of apple plants by replanting, weeding, hoarding, and pruning. Plant replacement is carried out on dead or killed plants (because they don't produce good fruit) by planting new plants to replace old plants. As many as 13 apple farmers (28.9%) chose not to spray and care for apples. They replaced apple plants with vegetable crops that were more resistant to rain, such as potatoes and carrots.

Various forms of apple farmers' behavior in responding the conditions are essentially adaptation behavior to climate change. This adaptation is an effort so that farmers do not experience massive losses, thus it threatens the sustainability of farmers' sources of income. These findings are in line with previous research, stating that farmers are adapting to climate change (Putri et al., 2018; Relawati et al., 2021; Ruminta, 2015). The forms of adaptation of farmers are quite diverse; some are adapted in cultivation behavior, for example in strawberries (Surya Negara et al., 2015). Farmers in Kabu[at]aten Majalengka also use shortcuts to deal with climate change by using growth regulators and pesticides intensively (Putri et al., 2018), as also done by apple farmers in this area (research site). In neighboring countries, Malaysia and China, rice farmers are also adapting to climate change in the form of rice cultivation behavior (Akhtar et al., 2018; He et al., 2020).

Economic Impact of Climate and Environmental Change

The economic impact of climate change was analyzed by SEM (Structural Equation Modeling) analysis. The results of the analysis meet the provisions of the validity, reliability, and goodness of fit of the built SEM model. All indicators in the latent variable meet the minimum requirement of 0.3, and the loading value is

greater than the cross loading value. The loading and cross loading values are presented in Table 2. According to Solimun et al. (2017), if the loading value > 0.3, it means the indicator meets convergent validity, and if loading > cross loading meets discriminant validity. The reliability of the research instrument met the criteria, indicated by the Cronbach Alpha value of 0.71.

Table 2. The value of loading and cross loading of indicators in SEM analysis

	Y (Economic impact)	X1 (Climate change)	X2 (Apple productivity)	X3 (Environment)
Y	1,000	0,000	0000	-0,000
X1.1	0,098	0,947	0,168	-0,042
X1.2	-0,513	0,976	-0,367	0,159
X1.3	0,657	0,745	0,325	-0,186
X2.1	-0,850	0,095	0,755	0,407
X2.2	-0,671	0,058	-0,446	0,365
X2.3	0,306	-0,038	0,781	-0,136
X3.1	-0,347	0,480	0,296	-0,702
X3.2	-0,149	0,041	-0,088	0,990
X3.3	-0,051	0,252	0,055	0,978
X3.4	0,160	-0,153	0,160	0,952

Information : The bold numbers are the loading values of each indicator on the latent variable.

Table 2. shows that the loading value of the indicator on each latent variable is greater than 0.3 and greater than the value of cross loading (the same row loading value in another column). The loading value also shows the strong correlation between the indicator and the latent variable. The greater the loading value is, the stronger the correlation between the indicator and the latent variable is, or the so-called outer model relationship (Solimun et al., 2017).

Furthermore, the goodness of fit of the built SEM model meets the suitability of the PLS-SEM model. The indication is that there are four significant inner model relationships, out of a total of six inner model relationships. Average path coefficient (APC) = 0.304, with P-value = 0.009, which means that the model is significant at the error level of 1%. Average block VIF (AVIF) = 1.18, acceptable if 5, ideally 3.3, meaning that there is no multicollinearity between latent variables used in the model.

The results of the SEM analysis are presented in Figure 4. The SEM results show that of the six inner model relationships, four of them are significant ($P < 0.05$). It means that the four inner model relationships show a significant effect. The value of path coefficient (β) which is the largest is -0.67 obtained on the effect of the variable X2 (productivity of apples) on Y (economic impact). It means that the higher the apple productivity is, the lower the apple price is. This relationship is profoundly significant at the significance level of $P < 0,01$. The subsequent order is the value of path coefficient (β) -0,43 on the relationship between X1 (climate change) and X2 (apple productivity), with a significance level of $P < 0,01$. Another lower significant relationship is the value of -0,30 with a significance level of 0,02. It means that X3 (environment) has a negative effect on X2 (apple productivity). A significant relationship with a significance level of $P = 0.03$ occurs in the effect of X3 (environment) on Y (economic impact). The other two inner model relationships are not significant because they have a P value > 0,05, namely the relationship between X1 (climate change) on X3 (apple productivity) and between X1 (climate change) on Y (economic impact).

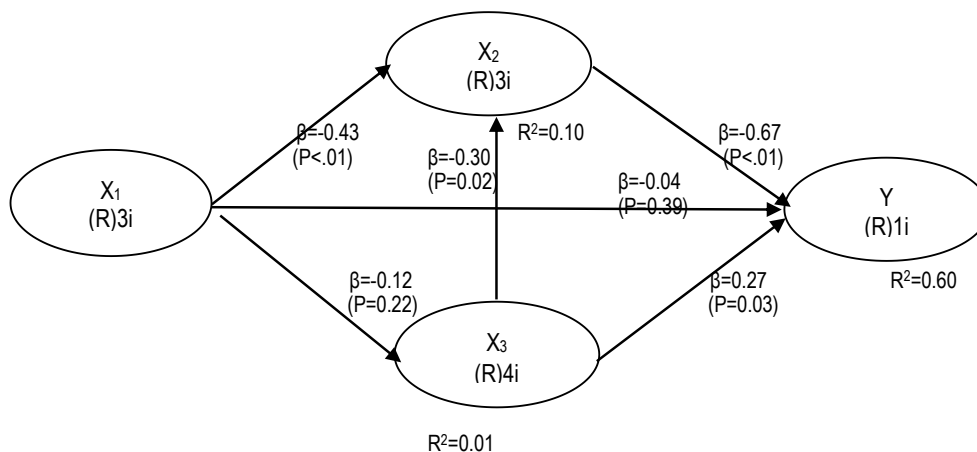


Figure 4. Empirical Model of Economic Impacts Due to Climate Change

- X₁ = Climate change
- X₂ = Apple productivity
- X₃ = Environment
- Y = Economic impact
- β = path coefficient
- P = alpha value (level of significance)

The results of the SEM analysis (Figure 4.) partially show that the contribution of environmental change to apple productivity is negative (0.3), smaller than the effect of climate change, which is negative (0.43). It means the effect of climate change is partially greater than environmental change. Changes in the environment and climate together cause productivity, the number of productive trees, and the level of apple production to have a very large impact on economic changes. Various previous research provide empirical support for this statement (Bayarçelik & Taşel, 2012; Habtemariam et al., 2017; Hălbac-Cotoară-Zamfir et al., 2019; Kabubo-Mariara & Karanja, 2007; Meckler, 2017; Pece et al., 2015; Zhang et al., 2017). The results of this study are also in line with the statement of Surmaini & Runtuuwu (2015) stating that three main factors of global climate change impacting the agricultural sector are: 1) changes in rain patterns, 2) an increase in extreme climate events (floods and droughts), and 3) an increase in air temperature and sea level.

Climate change is driving changes in the agricultural environment. The results of this study indicate that changes in the agricultural environment including a decrease in soil organic matter, an increase in pests and diseases, an increase in land use change and the use of inputs experience changes in direct proportion to climate changes such as temperature, rainfall, and humidity. This condition is in line with the findings of various previous research (Aryal et al., 2018; Budiastuti, 2010; Chandio et al., 2020; Santoso & Sabita, 2011; Shakhawat et al., 2019). In addition, climate change has a direct proportional effect on economic changes, in line with research conducted by (Bernetti et al., 2012). However, research results show that innovation and technology transfer to increase agricultural productivity as the environment changes due to climate change can sometimes have a negative impact on the environment (Ferreira et al., 2020). Therefore, the increase in the use of innovation and technology to increase agricultural productivity is a major concern in terms of the price to be paid for environmental damage.

CONCLUSION

The farmers possessed knowledge concerning climate change based on information mainly received from television and their perceived experience. Climate change causes the increase of warmer air temperatures, drought, and the need for product facilities, like fertilizers and pesticides. However, it causes the decrease of apple production. Climate change has a significant negative effect on apple productivity and the economic value of apples. The environment also has a negative effect on apple productivity at a lower level of significance. During climate change, apple productivity has a negative effect on apple prices, It means that the higher the apple productivity is, the lower the apple price will be. Hence, climate change caused the impact of a decrease in the economic value of local apple agribusiness in Malang Raya.

The given recommendation is continuous assistance to farmers in adapting to climate change resulting in a decrease in the economic value of apple agribusiness. Television shows are still being watched by farmers, and they can be used to provide knowledge concerning climate change and how farmers must adapt.

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