

# Enhancing accounting methodologies for agricultural entities in a changing climate

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**Abstract.** Climate change has a great impact on the agricultural industry as it has a direct impact on the production process of organizations, their business activities, operational and commercial performance. To date, this problem is becoming a global issue. Companies are striving to minimize the risks of climate change impact on operations by adopting new technologies. The increased global public attention in recent years - including from investors and regulators - on how businesses and capital markets are responding to climate change creates one of today's major challenges for professional accountants and auditors. They have a critical role to play in exactly how climate information will be disclosed in reporting in the future. The article suggests ways to improve the efficiency of implementing and reporting such information in business, examining real indicators of the level of implementation of climate change impact methods. It also proposes variables to be included in the analysis of APC companies' activities in the context of climate change.

## 1 Introduction

Climate change is no longer just an environmental issue; it has become an important financial driver for businesses across industries [1, 2]. As the global community grapples with the impacts of climate change, companies are under increasing pressure to disclose the impact of climate-related risks and opportunities in their financial reporting. Financial reporting is evolving to reflect not only companies' traditional financial performance, but also their efforts to ensure environmental sustainability and respond to climate change [4-6].

Traditional financial statements, including balance sheets, income statements and cash flow statements, provide an indication of a company's economic health [7]. However, they often fail to reflect the broader impacts of climate change on a company's operations, assets and long-term viability [8-10]. Recognizing this gap, there is a growing movement around the world to improve financial reporting systems that incorporate environmental, social and governance (ESG) factors [11, 12].

Companies are increasingly required to assess and disclose the potential impact of climate-related risks on their financial performance. This includes physical risks, such as

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extreme weather events, and transitional risks arising from the transition to a low-carbon economy. Understanding and effectively managing these risks is critical to the long-term sustainability of businesses [13, 14].

Climate change can affect the value of a company's assets, especially those that are vulnerable to climate-related risks. For example, real estate, agricultural land, and infrastructure may be subject to depreciation or impairment due to changes in weather patterns or regulatory measures to reduce carbon emissions [15-17].

Governments around the world are implementing regulations to combat climate change, ranging from carbon pricing mechanisms to mandatory ESG (environmental, social, governance) reporting requirements. Companies must disclose their compliance with these regulations and formulate strategies to adapt to changing environmental standards [18-20].

The impact of climate change on supply chains can have direct financial implications for companies. Accounting reports now need to reflect how supply chain disruptions caused by climate-related events, such as floods or wildfires, can affect production costs, revenues and overall financial performance [21-23].

Investors increasingly consider a company's ESG performance when making investment decisions. Thus, accounting statements should reflect how well a company is meeting the expectations of stakeholders concerned about climate change and sustainability. This includes information on green initiatives, energy efficiency measures and sustainability goals [24-26].

Forward-thinking companies realize that combating climate change can also provide opportunities for innovation and growth. Accounting statements should reflect investments in renewable energy, sustainable technologies, and other initiatives that allow a company to thrive in a low-carbon economy [27-29].

As climate change continues to reshape the business landscape, accounting plays a key role in communicating the financial implications of environmental sustainability [30, 31]. Integrating climate-related information into financial reporting not only helps companies manage risk, but also increases transparency, accountability, and sustainability. This evolution of financial reporting is consistent with a global commitment to sustainable development, and companies that embrace these changes not only better navigate the changing climate, but also meet the expectations of an increasingly environmentally concerned market [32].

## **2 Materials and Methods**

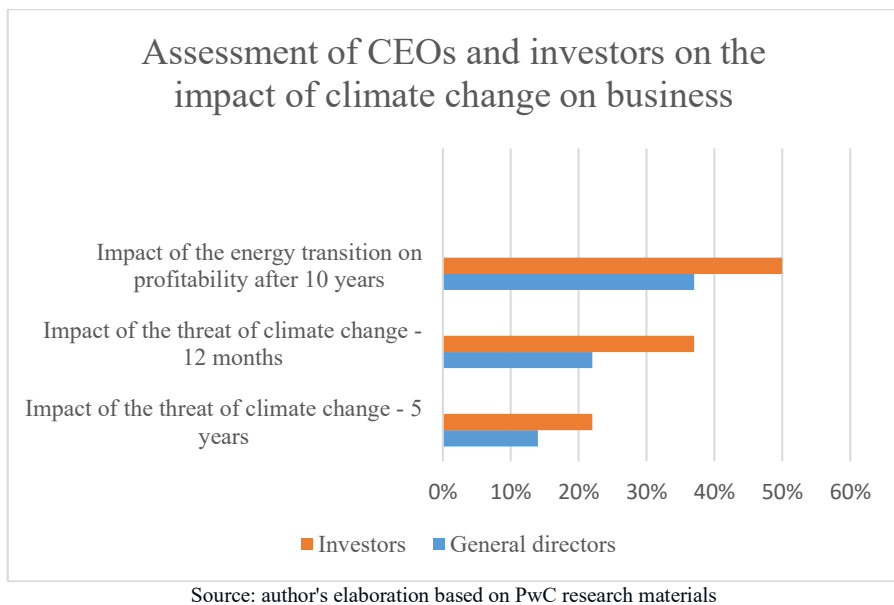
Climate change affects companies in two different ways. First, climate disruptions, such as rising temperatures and severe storms, can disrupt business activity [33]. And transition risks associated with factors that may arise in the transition to a low-carbon economy, such as new environmental regulations and the influence of climate change-oriented customers and investors, can undermine the strength of a company's business model [34-36]. There is a need to analyze from management personnel and investors whether the impacts of these complex factors will have similar financial implications. This should be done by analyzing the views of company executives on the extent to which their companies will be exposed to financial risks due to climate change, both physical hazards and transition risks - over the next year and the next five years.

It should also take into account the opinion of company executives on how much the energy transition will affect the profitability of their industry over the next ten years. A similar analysis should be conducted among the companies' investors.

At all three-time horizons, investors expect climate change and the energy transition to have a greater impact on companies' financial performance than CEOs do. For the 12-month climate threat, investors are 1.6 times more likely to indicate higher exposure to financial

losses than CEOs. For the five-year climate threat, investors were nearly twice as likely to indicate a higher level of exposure. Regarding the ten-year impact of the energy transition on company profitability, investors were 1.4 times more likely to indicate that the magnitude of the effect would be larger. Investors see climate action as effective and want it to be a business priority, but relatively fewer CEOs report progress in their annual reports or other documentation. When it comes to investors, businesses must take action on climate change.

For example, in Figure 1, we analyzed a survey on potential threats and potential profitability from climate action conducted by one of the largest international audit and consulting firms, PricewaterhouseCoopers, conducted among the management of client companies and their investors. It is important to note that the results of the survey among CEOs and investors led to different results, which indicates the need for more in-depth study of the problem among the management of companies.



**Fig. 1.** Survey of CEO and investor perceptions of potential threats and potential profitability from climate impacts.

Among investors, 44% of respondents agreed that businesses should make reducing greenhouse gas (GHG) emissions from their operations and supply chains one of their top five priorities, according to research from global advisory and assurance firm PwC. Overall, reducing GHG emissions ranked fifth on investors' list of business priorities, behind innovation (in first place, 83%) and profitable operations (in second place, 69%). Moreover, a solid majority of investors said they believe actions taken now would be effective in preparing for climate risks. Chief among the various actions companies could take were implementing initiatives to reduce emissions (named by 75% of respondents), introducing new green products and processes (73%) and developing an enterprise-level climate strategy (69%). Notably, a relatively smaller percentage of CEOs reported that their companies were making progress on these same actions.

It is possible that some of the differences between CEOs' and investors' predictions of climate risks in 2022 reflect the urgency of other threats such as inflation and macroeconomic instability. In 2021, a third of CEOs surveyed said they were "very" or «extremely» concerned about climate change as a global threat that could negatively impact their companies in the next 12 months - in 2022, the result was only 14%. Nevertheless, the

discrepancy between investors' views on what climate change measures are effective and executives' assessment suggests that executives may want to rethink their approach to climate issues.

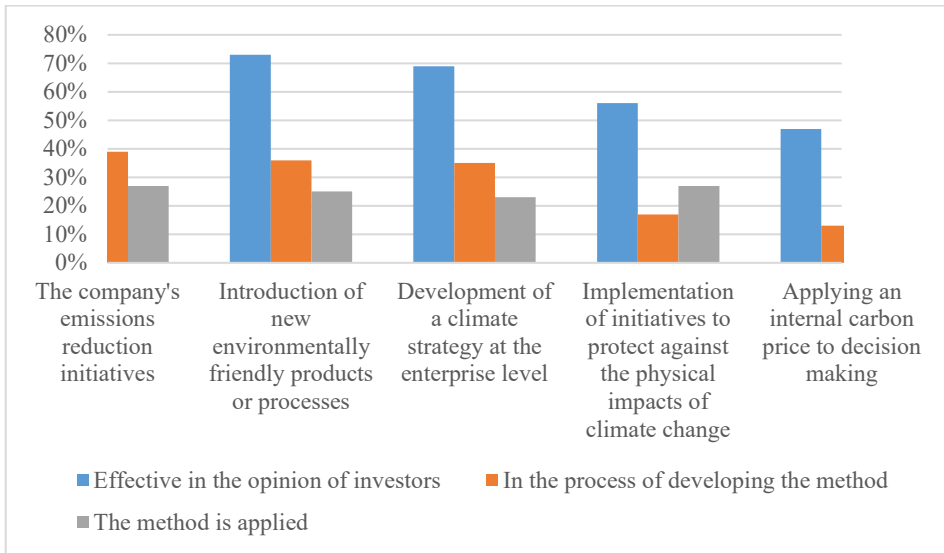
### **3 Results**

The results of the analyzed studies allow us to formulate a list of actions to be followed by both company managers and investors in order to most effectively achieve the set goals and results:

1. Outline a clear financial rationale for climate change actions. A small percentage of CEOs and investors said they see climate change as a threat to business in the next few years. But a growing number of both groups realize that the energy transition could have a significant impact on profitability over the long term. More than a third of the CEOs we surveyed (37%) said the energy transition will have a significant or very significant impact on their industry's profitability over the next ten years, compared to 14% who see climate change as a risk over the coming year. Investors agree, with 50% saying the energy transition will have a large or very large impact on corporate profitability over the coming decade. Keep in mind that investors' top two priorities for companies are profitability and innovation, with reducing greenhouse gas emissions ranking fifth. When making the case for climate change action, CEOs should justify their logic with the financial implications of both climate risks and climate opportunities;

2. Maintain and demonstrate financial discipline. For CEOs, stating that climate programs are value-driven is only a starting point. Investors also expect executives to demonstrate positive financial performance over time. Indeed, four out of five investors (81%) say they would agree to a reduction in total returns of no more than one percentage point for companies in their portfolio that take sustainability actions relevant to their business. Many investors also say they want companies to disclose the impact of sustainability risks and opportunities on financial reporting assumptions (70%), the relevance of sustainability factors to their business model (69%), and the external environmental or social impacts of the business (60%). To meet these rigorous expectations, business leaders need to exercise discipline in managing and describing the financial impacts of their climate programs;

3. Improve the relevance and quality of sustainability reporting. According to research and surveys, few investors trust sustainability reports and disclosures published by companies. For example, Figure 2 analyzes investors' expectations of actions by CEOs and their assessment of their performance on climate change. The general conclusion that can be drawn from this analysis is that the information published by companies on the business impacts of climate change cannot be fully credible due to the lack of mandatory publication and lack of auditing of indicators. Less than 40% of investors said that disclosure of greenhouse gas emissions reductions is effective. Only 61% said they use company sustainability information to a moderate, great or very great extent when assessing how companies manage risks and opportunities; many more respondents said they rely on financial statements (89%), discussions with company management (81%), non-financial reporting other than sustainability disclosure (80%), and even third-party data sources (79%).



Source: author's elaboration based on PwC research materials

**Fig. 2.** Investors' expectations of CEO actions and assessment of their effectiveness in terms of climate change.

Investors also state that the most effective approaches to impacting climate change, in their opinion, would be the introduction of new environmentally friendly products and processes and initiatives to reduce company emissions [5, 6, 7]. If we talk about the methods that some companies already apply or the methods taken to work, it is worth noting a big difference in the extent to which investors consider an item important and effective in application and the extent to which it is used in companies in reality. While 74% of investors consider company emissions reduction initiatives to be effective, only 27% and 38% of companies respectively have implemented and are implementing these initiatives.

The negative impact of climate change carries great risks for companies and the financial sector, as there has been a negative trend of increasing natural disasters with devastating impacts on both the entire business sector and individual companies over the last twenty years. However, proposed measures to combat climate change often pose equal threats to industries and businesses around the world. As such, climate risks have been particularly significant for several years now, at all levels: from global and governmental, to business sectors and industries.

Most notably, 87% of investors said they believe sustainability reporting contains at least some elements of exaggeration of a company's environmental merits. Disclosing more of the information that investors care about could go some way to raising the profile of sustainability reporting. So could obtaining a higher level of assurance: 75% of investors said that an independent reasonable assurance opinion (the same level of rigor as financial statements) would give them a moderate or higher level of confidence in a sustainability report. Only 54% said they would get that level of confidence from a sustainability report that received an independent opinion with limited assurance, which is typically the level of assurance that many companies provide today.

By some measures, investors are more concerned than CEOs that climate change will have meaningful impacts on business. These concerns should motivate CEOs to not only take action on climate, but also to provide a compelling rationale for their decisions. By linking climate action to value creation, CEOs can provide the leadership that capital markets expect.

Since climate change directly affects the state of the land (fertility, dryness, floods, etc.), Russia's well-established agricultural sector should find it particularly important to analyze

its consequences. There might be several simultaneous effects of climate change on crop productivity in Russia. The main negative effect is an increase in very unfavorable weather events, especially droughts. Severe and prolonged droughts can reduce the gross grain output in the key grain-producing regions by 40–50%. Another risk element is the increasing damage that pests and diseases do to agricultural crops. Climate change and the thawing of permafrost cause pests' habitats to expand and their populations to increase.

The yearly total of active surface air temperatures rose during 1956–1976 and 1996–2021, which resulted in a significant change in the Italian locust distribution boundaries towards the north. According to further climate change forecasts for the twenty-first century, the Colorado potato beetle is expected to expand widely, with significant growth expected in the northeastern, eastern, and northern regions.

But according to Russia's Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet), there are three main consequences of climate change that might, at least in part, be advantageous for agriculture:

1. Prolongation of the vegetative phase and the quantity of heat accessible to farming crops;
2. Heating of the winter atmosphere, influencing the manner in which farming crops survive the winter;
3. Changes in the amount of precipitation experienced during the cold and warm seasons, resulting in altered moisture conditions.

2. Over the past 20 years, climatic change has improved grain and leguminous crop yields nationwide, with the exception of the Central Federal District (18 sub-federal territorial entities of Russia centered around Moscow, the capital of Russia).

The largest improvement was observed in the winter grain yields. In certain regions of the Volga and North Caucasus, the rise was between 10% and 15% over a ten-year period. Evidence does, however, seem to indicate that the effects can be contradictory. Between 1998 and 2019, there was no climate-driven increase in agricultural production in the European part of Russia because to aridization and high thermal regime stress. The expansion of the growing season and the increase in thermal resources encouraged the growth of bioclimatic potential at the same time.

For a country the size of Russia, regional differences in agricultural productivity responses to climate change can be rather considerable. In terms of grain yield growth rates (2.2–2.6% over a ten-year period), the Southern Federal District and the Volga were the national champion areas. But dryness is also likely a threat to the southeast of Russia's European part.

It is noteworthy that winter wheat poses less risks than spring wheat. Thus, between 1975 and 2010, winter wheat had strong growth, with the North Caucasus and the south of the Volga region experiencing the largest increases.

Climate-related increases in sunflower and sugar beet yields were also observed in European Russia between 1996 and 2010.

Corn yields in the Volga and Central Federal Districts increased while they decreased in the Southern Federal District due to an intensifying summer drought.

## 4 Discussion

Russia has emerged as a significant exporter of agricultural goods throughout the last 20 years. By 2017–2018, Russia was contributing 10–13% of the world's grain exports and 20–23% of the wheat. What matters is that this global commercial success was not the result of intensive development. Grain yields in Russia grew dramatically from 1.63 t/ha in 1987–1991 to 2.81 t/ha in 2018–2020, despite the country's grain harvested area declining from 58 million hectares in 1987–1991 to 41 million hectares in 2018–50. This is a result of the 2000s' economic expansion, which enable it to employ fertilizers more frequently and to acquire

better equipment, seeds, and farm management techniques. Over the past 20 years, the yields of all main agricultural products have significantly increased as a result of all these variables.

Among the scientists who study how climate conditions affect agricultural production are agronomists, meteorologists, and economists. These researchers have different areas of expertise in agricultural productivity. Despite the divergent opinions, most studies use econometric modeling techniques. A commonly used definition of regression is one in which yield is the dependent variable and other climatic factors are the predictors. Rainfall and temperature are the two climate variables that are most often considered. Additional variability in the selection of components is usually accounted for by the growing conditions of a particular crop. For example, particularly hot days may have a greater detrimental effect on spring cereals, but fall and winter temperatures may have a greater effect on winter wheat.

The study's focus has a significant impact on the technique used to assess the causal relationship between climate change and agricultural productivity. When concentrating on the national level, time series analysis is made simpler by the abundance of large datasets. Conversely, regional analysis is usually associated with many data restrictions. This matter is particularly relevant to economic study in Russia. The socioeconomic data for the same areas of the USSR and Russia are not entirely compatible.

Furthermore, because of the decade's economic crisis and hyperinflation, any monetary figures from the 1990s cannot be compared to those from previous periods. The purpose of this study is to assess the impact of various factors on agricultural output in Russian regions during the previous 20 years. Precipitation and temperature have been the only two factors examined in the bulk of previous study. This article, on the other hand, considers a broader variety of factors, including global and Russian climatic conditions, producer price for key crops, and technological advancements.

Table 1 proposes a classification of variables that can also be included in the analysis of APC companies' performance under climate change by groups of factors and a description of each variable. It presents only a sample of factors that could also be additionally included in the calculations of specialists. For example, we additionally included such factors as overall agricultural productivity, global climate patterns, technology, and prices. Also, we believe that special attention should be paid to climatic peculiarities of different regions of Russia, which, as described earlier, have completely different soil and climatic peculiarities due to the large territory.

**Table 1.** Classification of variables to be included in the analysis of APC companies' performance under climate change.

Group	Variables	Description
<b>Agricultural productivity (dependent)</b>	Grain yield	Yield of main crops of Russian agriculture: cereals, potatoes and vegetables, tons per hectare
	Vegetable yield	
	Potato yield	
	Grain harvest	Gross yields of main crops of Russian agriculture: cereals, fruit and berry crops, potatoes and vegetables, thousand tons
	Vegetable harvest	
Potato harvest		
<b>Climatic peculiarities of Russia</b>	Temperature in January	Average monthly air temperature in January, °C
	January precipitation	Precipitation in January, mm
	Temperature in July	Average monthly air temperature in July, °C
	July precipitation	Precipitation in July, mm
<b>World climate models</b>	CO2	Average carbon dioxide content in the atmosphere
	El Niño	El Niño (fictional) phenomenon
	La Niña	Events of La Niña (fictional)
<b>Technologies</b>	Harvesters	In units of 1000 hectares of crops, the number of combine harvesters

	Tractors	Tractor density per 1000 hectares of arable land (units)
	Mineral fertilizers	The mineral fertilizers used by agricultural organizations provide 100% of the nutrients needed for one hectare of crops per kilogram.
	Organic fertilizers	Tons of organic fertilizers are utilized by farming companies for every acre of crops.
	Agricultural grounds	Cultivated area, thousand hectares
<b>Prices</b>	Oats price	Manufacturer prices in Russia, USD/ton
	Wheat price	
	Potato price	
	Price of vegetables	

Source: author's elaboration on the research materials.

Each regression illustrates the degree to which local and global climatic conditions impact gross yields and primary crop yields. The exceptionally high January temperatures have a major impact on the increase in crop yields and total yields. According to Roshydromet, Russia's temperature is increasing almost 2.5 times faster than the global average. Future agricultural sector growth in Russia may be significantly influenced by the country's milder winters, especially in the Siberian, Volga, and Ural regions. This finding for Russia is consistent with studies carried out in other countries with similar climates. Winter crops in Finland and Canada are predicted to have grown greatly by the middle of the twenty-first century.

The opposite of the global warming trend is droughts. Because of the predicted increase in climate aridity, there are increasing risks to agricultural output. Most of the variables in our models are negatively impacted by the substantial July temperatures. The main threats to Russia's crop production are increasing aridity in the southwest, which produces the majority of the nation's agricultural goods, and an increase in the negative impacts of agricultural crop pests and diseases, which can spread to other areas and have an impact there.

Winter precipitation had a pronounced negative effect on all crops, but July precipitation had almost no effect at all, save for yields of potatoes. Since most studies have shown that summer precipitation increases agricultural production, this result could be explained by the effect of previous months' precipitation that has gone unnoticed. Geographical differences in crop responses to precipitation are also influenced by a combination of latitudinal temperature gradient, altitudinal precipitation gradient, and technical water infrastructure, including irrigation systems and hydrological networks.

Russia is extremely vulnerable to climate change due to its geographic location. El Niño and La Niña, two global climatic variables, have a big influence on Russia's agriculture, particularly on grain yields and gross yields.

## 5 Conclusions

Thus, we may conclude that climate change has a favorable effect on Russia's agricultural productivity, however it is challenging to include all factors. The following sums up other aspects that were overlooked but might have a big influence on the outcome:

1. Including additional agricultural productivity-related parameters in the data collection. Unaccounted elements like labor, the usage of transgenic seeds, or irrigation techniques might skew the estimations. This holds particular significance when comparing regions across borders. For instance, due to their export-oriented economy, Russia's southwest regions may employ more agricultural techniques to boost production;

2. Increasing the amount of data that has been divided into explanatory and dependent variables. We have already discussed the uneven results for combines and cropland that are not crop-specific. This also applies to grain yields. For example, spring and

winter wheat respond to the weather differently;

3. Making more use of weather data. While the weather during the coldest and hottest months of the year describes yield and gross yield patterns quite well, models that take into consideration temperatures and precipitation throughout the year are more accurate;

4. Considering heterogeneity in space. Due to its vast size, Russia is a tremendously varied country, and different parts of the nation are experiencing distinct consequences of climate change.

5. Playing around with different settings. Polynomial or logarithmic specifications may be taken into consideration, as there is data indicating that the link between agricultural yields and climate is not linear.

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