A Methodological Approach for Estimating the Costs and Benefits of Climate Adaptation Measures

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Abstract

This paper investigates on the effectiveness of climate adaptation measures in countering climate risk damage. Our paper provides a-depth costs and benefits assessment associated with the adoption of the climate adaptation measures in Italian farms. Concerns about global warming are currently attracting interest of global policy makers and the issue is central to the political and scientific debate. This paper use methodology that will be implemented in LIFE project "ADapation in Agriculture"- ADA which aims to help improve adaptation to climate change and promote sustainable and inclusive growth in the agricultural sector. In this context, we provide a methodology framework for costs and benefits assessment of adaptation measures to climate change and their economic and environmental effects at the farm-level in Italy to improve farmers ability to face current and future climate risks. We provide an exemplary estimation model based on entity of damage avoided - deriving by adverse climatic events with the climate adaptation measures adoption. The results provide a methodology to represent costs and benefits associated with the reduction of the climatic risk that countering the adaptation measure. The use methodology approach could be to support farmers in choosing to adoption of appropriate climate adaptation measures. This framework is a prerequisite for identifying the specific support interventions for adaptation measures, mainly deriving from rural development measures to which farmers will be able to access. Our challenge is to outline specific measures for the agricultural sector, to counteract impacts of climate change also at local level.

Keywords

Climate change, adaptation measures, costs/benefits assessment

1. Introduction

The overall aim of this paper is to investigate on the effectiveness of Climate Adaptation Measures (CAM) (EU COM 2021/82; Reg. CE 2021/1119) in countering climate risk damage. Our paper provides a-depth costs and benefits assessment associated with the adoption of the CAM in Italian farms. Concerns about global warming are currently attracting interest of global policy makers and the issue is central to the political and scientific debate. According to a Eurobarometer survey of 2021, after diseases, the economy and world hunger, the climate is considered the fourth emergency in Italy. However, in Italy, eight out of ten people consider climate change a "*very serious*" problem (84%, higher than the EU average of 78%) and more than six out of ten respondents (63%, equal to the EU average) consider it to be responsible national governments rather than the European Union (56%, in line with the EU average of 57%). It's extremely clear and well-known that agricultural is responsible of climate change but it's also vulnerable (Parker *et al.*, 2019). In the next decades, the intensification of hard-to-predict extreme weather events will put pressure on the agricultural sector, impacting

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farmers' incomes and farm's survival. According to a Special Report by the European Court of Auditors, despite more than 100 billion euros being devoted to climate change mitigation (over a quarter of EU agricultural expenditure in the 2014-2020 period), for over ten years, greenhouse gas emissions produced by agriculture have not decreased. The report shows that most of the measures financed by the Common Agricultural Policy (CAP) have limited potential for mitigating climate change; the CAP, therefore, has failed to incentivize the adoption of effective environmentally friendly practices. However, the fight against climate change will continue to be one of the strategic objectives of the CAP even in post 2020. Following a public consultation launched by the European Commission on the CAP Future, in 2017 the Commission has presented three legislative proposals for the CAP 2023-2027 reform, approved after three years of negotiations. The Commission included three general objectives in its reform strategy, including "*to bolster environmental care and climate action and to contribute to the environmental and climate objectives of the EU*" and nine strategic goals focused on social, environmental, and economic factors, including "*contribute to climate change mitigation and adaptation*" (Reg. 2021/2117). In this context, scientific research on the effectiveness of climate adaptation measures for farmers contributes to the debate on the reduction of economic and environmental risks related to climate change under different fields of analysis (De Leo *et al*., 2022; Giuca *et al*., 2022). At the first, the scientific literature suggests that climate change impacts on agriculture to be site-specific (El Chami and Daccache, 2015). For this reason, adaptation measures show efficacy by more heterogeneous results and the adopation vary across regions and agrosystems. A field of existing literature focuses on the factors that drive the willingness to take adaptation measures and the socio-economic (Frame et al., 2018) and agronomic conditions (Ulukan *et al*., 2008; Dednath *et al*., 2021) influencing their adoption. Kabir and Alam (2021) provide a conceptual model for identifying the determinants affecting farmers in the adoption of adaptation measures to climate change. In the same direction, a field of existing literature focuses on the factors that drive the willingness to take adaptation measures. The results show that farmers' adoption of adaptation measures appears to be influenced by socioeconomic factors such as age, education level, household size, household income, farm size and agricultural experience (Bryan *et al.*, 2009; Masud *et al.*, 2017 [a], 2017 [b]; Kabir *et al*., 2020). This consideration suggests that climate change measures are a robust part of public policies, at local, national, and global levels.

2. Data and Research Methodology

The methodology illustrated will be implemented in LIFE project "ADapation in Agriculture"- ADA (execution stage) which aims to help improve adaptation to climate change and promote sustainable and inclusive growth in the agricultural sector. In this context, we provide a methodology framework for costs and benefits assessment of adaptation measures to climate change and their economic and environmental effects at the farm-level in Italy to improve farmers ability to face current and future climate risks. The methodology approach is based on collect cost and benefit data deriving from: i) desk research; ii) questionnaire administration with CAWI methodology (Computer Assisted Web Interviewing). The data are obtained through questionnaires and cross-sectional data are collected from Italian FADN detector. The questionnaire includes questions closed and open-ended response and used samples and standardized questions to carry out a structured interview; iii) open interview to agricultural experts.

Data collected, stored in a database, are:

- The range of costs to be incurred for the implementation of the measure[2].
- Degree of effectiveness of the measure in relation to the risks (high, medium, low).
- Further economic benefits.
- Environmental benefits.
- Possibility of public funding.

[2] We collect range investment costs, and average annual cost per hectare. These annual costs taking into account the depreciation of the investment and the maintenance cost of the investments.

This collect data are used in an exemplary estimation model to evaluate cost and benefits of CAM adoption. The exemplary estimation model is based on entity of damage avoided - deriving by adverse climatic events - with the CAM adoption. Adverse weather events are growing frequently. Considering the average of the yields' losses in agriculture in last year with strong effect on income (European Environmental Agency, 2021), for simplified our model assume that adverse climatic events can cause damage on average equal to or greater than 30% of the value of the farm's production with a high likelihood. The damage is calculated using FADN data and the average farm value Gross Production farm is considered for type of farming and its economic size.

The benefit of each measure is calculated on estimate effectiveness of the measure to prevent/reduce such damage.

The following assumptions were made regarding effectiveness of the measure:

- High = capable of reducing the damage from 70% to 100%
- Medium = capable of reducing the damage from 30% to 70%
- Low = capable of reducing the damage from 10% to 30%

In our approach we considered the average damage reduction based on the previous assumptions.

Furthermore, other economic benefits are considered. Benefits related to the improvement of production quality, the possibility of benefiting from CAP payments, the environmental benefits that can have positive economic repercussions, as they are increasingly appreciated and requested by consumers.

The adoption of the measure could entail economic benefits independent of the occurrence of the adverse climatic event. The measure could provide a qualitative improvement of the production (organoleptic properties, better size that allows a better placement on the market etc…) and / or an increase in yields. The economic value of this benefit depends on the adaptation measure, as well as on the specificity of the farm, so can be suitably valued based on the measure considered.

The possibility of receiving public contributions deriving from the CAP must be considered (e.g.: measures of Rural Development Program) and this public support differs according to the adaptation measure considered.

Furthermore, we wanted to recognize a small economic value, of symbolic type, that we could value in a little percentage of the value of production, that we will be tailored for each measure, to any environmental benefits brought about by the implementation of the measure.

Aware of the difficulty of estimating the economic value of these benefits, we felt right to consider their contribution.

In fact, environmental benefits are increasingly pleasant by consumers and can therefore have positive economic repercussions as they are increasingly appreciated and requested by consumers. In the long term they can also increase yields.

Finally, the overall average benefit is compared to the average cost to be incurred for the adoption CAM.

In our exemplificatory estimation model we have assumed the follow possible average annual costs per hectare:

- low: 250
- medium: 500
- high: 1000
- very high: greater than 2000

The cost per hectare was multiplied by the average UAA (utilized agricultural area) of farm type and class of economic size. The farm average UAA come from FADN data (2017-2018-2019).

Taking into account the average annual costs of implementing the measures and the related benefits is possible to calculate the follow evaluation indicators:

- Impact of the net benefit[3]/ on cost (net benefit/cost)
- Cost impact on gross production (cost/gross production)
- Incidence of the benefit on the gross production (loss avoided)/(net benefit/gross production)

[3] Net benefit = Benefit – Cost.

3. Results and Conclusions

The results provide a methodology to represent costs and benefits associated with the reduction of the climatic risk that countering the adaptation measure. The use methodology approach could be to support farmers in choosing to adoption of appropriate CAM. This framework is a prerequisite for identifying the specific support interventions for adaptation measures, mainly deriving from rural development measures to which farmers will be able to access.

This paper contributes to the research issue providing a methodological framework and in-depth assessment of adaption measures capability to reduction economics and environmental damage due to climate risk.

In this paper we apply the methodology approach to the following type of farms: open field horticulture, fruit, wine. Table 1 shows the data that were used to estimate the cost-effectiveness of adopting the measure.

Table 1

FADN data used for the simulation of the cost-effectiveness of adopting the measure (average values)

Supply chain	Farm size	Production value (€)	UAA (ha)
Open field horticulture	Large	260.790	20,2
Open field horticulture	Medium	73.161	3,5
Open field horticulture	Small	24.964	1,5
Fruit	Large	248.332	23,7
Fruit	Medium	65.321	7,0
Fruit	Small	21.908	2,8
Wine	Large	240.397	29,0
Wine	Medium	47.128	7,7
Wine	Small	16.566	3,5

Considering only the benefit deriving from the effectiveness of the measure in avoiding probable damage, estimated at 30%, the results obtained are shown in table 2.

Table 2

Impact of the net benefit on cost

Supply chain	Farm size	Hight effective				Medium effective				Low effective			
		250	500	1000	2000	250	500	1000	2000	250	500	1000	2000
Open field horticulture	Large	*****	*****	*****	***	*****	*****	***	#	*****	***	#	##
Open field horticulture	Medium	*****	*****	*****	****	*****	*****	*****	***	*****	****	**	##
Open field horticulture	Small	*****	*****	*****	****	*****	*****	****	**	*****	***	#	##
Fruit	Large	*****	*****	****	**	*****	*****	***	#	****	**	#	##
Fruit	Medium	*****	*****	****	**	*****	****	**	#	****	**	#	##
Fruit	Small	*****	*****	****	*	*****	****	**	#	***	#	##	##
Wine	Large	*****	*****	****	*	*****	****	**	#	***	#	##	##
Wine	Medium	*****	*****	****	#	*****	***	#	##	**	#	##	##
Wine	Small	*****	****	**	#	****	**	#	##	**	#	##	##

If benefits minus costs is higher than cost the legend is: for values from 0% to 10% = * = convenient; for values from 10% to 50% = ** =good; for values from 0% to 100% = ***very good; for values from 100% to 200% = **** high; > 200 =*****= very high. If the costs exceed the net benefits the following legend should be considered when assessing the cost-effectiveness of the measure: for values from 0% to 50% = consider the value of additional benefits; for values from >50% consider farm specificities.

The simplified model considering the supply chains involved (fruit and vegetable; wine) the main considerations emerge.

If the adaptation measure is highly effective its adoption for farms is convenient for each average costs considered. It's exception medium/small wine farms in case of cost per hectare is very high. In this type of farm, the convenience could be achieved by considering any additional benefits. If the measure has low effectiveness and implementation costs are high and/or very high, the adoption of the measure should be evaluated according to farm specificities and considering any further benefits. In case of a high average cost the presence of additional benefits might be sufficient for horticultural and fruit farms.

In the case of a measure with moderate effectiveness and very high costs the farm specificities must be considered.

The limitation of the model consists in its exemplification due to the use of average data and estimates that cannot be replaced by the structural, economic and patrimonial characteristics and also by the productive context in which the farm is situated. However, the model findings provide interesting information for adaptation measures.

Yet, it should provide a valuable tool to support environmental economists and policies. Climate changes directly affect productivity by affecting the profitability of farmers, especially small and medium-sized farmers, and their ability to survive, also negatively affecting the quality of production. This consideration suggests that climate change measures is a robust part of public policies, at local, national, and global levels. In addition, an overview of possible policies to support adaptation to climate change in agriculture was created. In line with the EU adaptation strategy (EU COM 2021/82), our paper contributes to scientific literature to make farmers more resilient to climate change. Our challenge is to outline specific measures for the agricultural sector, to counteract impacts of climate change also at local level.

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