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Global climate change and sustainable management of agriculture in a highly developed mountain environment

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Background and objectives: Social, economic and ecological change is accelerating in highly developed (anthropised) Alpine areas, changes that combined with the effects of the predicted climate change threaten to alter crop quality, the distribution of existing species, enhance the invasion of exotic species, and cause changes in land use and cover that will reduce biodiversity. Mountain regions are of local and global importance. They provide resources to half of humankind; including water, energy, food, food products and places for tourism. They are global centers of ecosystem complexity and biodiversity (in the broadest sense). Their steep slopes and sharp gradients make them highly diversified, but fragile ecosystems that are exploited for natural resources and used for recreation activities. In addition, globalization is contributing to the marginalization mountain communities and lessening the competitiveness of the farming sector. Nevertheless the agriculture continues to play a vital role in preserving the environment and landscape. The alpine agriculture has strengthened its multifunctional role as provider of a mix of private goods and public services, most of them are crucial for the tourism sector. Scenarios and methods of analysis to cope with the multiple factors of global change are being developed and will be required to translate the current knowledge on climate change at the mega scale into local economic scenarios at the local level, a requirement for making sound policy decisions for environmental protection and sustainability. ENVIROCHANGE is a project based on a multidisciplinary approach to provide tools and information to understand the vulnerability to climate change of the agriculture environment at a regional scale and assess adaptation options suitable for local socio-economical conditions. The region of Trentino (northern Italy) was selected as case study. Currently, most of the studies focused on the impact of climate change at a global level, without considering the regional levels, therefore this project will fill an important gap, not only providing specific information on Trentino's situation but also developing methodological approaches to be used in the future or in other similar areas. The objective is to create tools to forecast the potential impact of global changes on a regional territory for a sustainable development and to propose possible adaptations.

Results: This project is composed of the following parts:

1. The development of a tool (ENVIRO), based on ecological models, GIS and remote sensing, for the assessment of climate change impact on crop quality, plant protection and farm economy at the regional scale;
2. The evaluation of crops, areas and farms that may be affected by climatic and global changes and if sustainability of crop production in Trentino will be "of concern";
3. The estimation of current vulnerability, to provide scenarios for the short term (up to 25 years) and to propose adaptation strategies;
4. The formulation of adaptation strategies taking into account the impact of climate change at the multitrophic level, the availability of existing tools and the development of innovative approaches based on the proposed scenarios;
5. The evaluation of economic consequences of the most likely factor to be affected in the short term by climate change (i.e. plant quality, pest and diseases and land use change) at the farm level and at the local system level;
6. The evaluation of the economic, environmental and social sustainability of the proposed strategies;
7. The identification of a set of policy instruments necessary to support the choice of the most sustainable strategies and the evaluation of social acceptability of these instruments.

Initial results will be presented. ENVIRO is initially developed as a basic skeleton. ENVIRO has a modular structure where the factors are implemented by single software modules (or layers). Each factor (module) can assume different values based on a model which describes its dependency on weather parameter. These values can be further analyzed or visualized on a raster map of Trentino. Interactions among factors (F1×F2)

are modules by themselves described by models of interaction. The values obtained by running a model of a factor on weather parameters, corresponds to a prediction. In this project, ENVIRO will use weather scenarios. An inventory of quality indices, pest and pathogens, and socio-economic factors, from currently available, adapted or newly constructed models, is under construction. Initially ENVIRO will analyze a selected crop (grapevine) were several models are already available and validated. In the pipeline additional crops and factors that are studied in the project will be added. These factors and relative interactions represent areas were little biological is known or never been exhaustively explored before. The multitrophic interactions are another challenging aspect that will be included in ENVIRO by the end of the project. Theoretically each factor that is weather-dependant and the factors that depend on it could be included by ENVIRO. In parallel to the biological aspect the socio-economic evaluation will be carried out. Each change in crop quality and, pest and pathogens will be evaluated with respect to impact on crop yield and farm income (both calculated from farm accountancy). To propose adaptation tools or strategies other than agronomical and market aspects, the project will also evaluate farmer's perception of climate change, how they are affected by climatic conditions, their acceptance of the adaptive strategies and the constraints and opportunities for enhancing their adaptive capacity. The modeling of the farmers' behavior in response to climate variation and to the consequent change in pest ecology (type and density) and quality will be included in ENVIRO. Once an adaptation strategy is proposed, we can evaluate the overall sustainability at the farm and at the provincial level and compare it to a no-adaptation scenario. When an alternative crop is proposed as the adaptation (especially in case of extreme events) the project will evaluate the agronomical, management and socio-economical aspect of its introduction in Trentino and therefore its feasibility. Conclusions: The originality of ENVIRO tool is represented by a new approach in managing this kind of data. It is based on a modular structure where each module is a factor (such as an insect, a quality index like sugar content, etc., but also the revenue of a farm). If these factors, as well as their interactions, are weather parameter-dependent and models are available they can be easily calculated and changes presented on a map thanks to the GIS. It will be possible to study, calculate and visualize the effect of a change in a weather dependent phenomenon and their relative agro-ecological, socio-economic and sustainability impacts. Currently, agriculture plays (directly and indirectly) a key role in Trentino's economy and in the preservation of its environmental capital. Predicted increases in temperature and decreases in precipitation due to climate change will add complexity and uncertainty to the agriculture system, threaten its sustainable management and have a negative impact on the environment, and hence on tourism. The impact of climate change on the melting of glaciers, reduced water availability, decreased biodiversity, and on plant stress and yield are well known, but climate change will also influence crop quality and dynamics of pest and diseases. Furthermore, competition from a global agriculture will further hamper the development of sustainable approaches to counteract global change. Adaptation will be necessary for a sustainable development of Alpine regions.

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