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AN ECOSYSTEM SERVICE-BASED APPROACH TO DESIGN AGRI- ENVIRONMENT-CLIMATE PAYMENTS FOR THE RURAL DEVELOPMENT PROGRAMS 2014-2020. THE CASE OF THE AUTONOMOUS PROVINCE OF TRENTO

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Abstract – The justification for measures addressing Agri- Environment-Climate payments (AEC) is a crucial issue for authorities working at the Rural Development Program (RDP). The RDP 2014-2020 offers the possibility to include environmental benefits and externalities as elements that drive decision-making. Such benefits and externalities include the ecosystem services (ES) provided by farming practices in semi-natural ecosystems such as alpine pastures and mountain hay meadows. An approach based on ES is proposed to support and to account for AEC measures in the Autonomous Province of Trento, relying on decision models and scenario analysis. The method is still in development and is currently being tested as to its effectiveness. In the present paper, however, we present the approach and the case study area, with preliminary insights and expected results. The decision framework consists of livestock management and alpine grassland use; its objective is the sustainable production of fodder, compatible with conservation of grassland biodiversity. In addition to habitat for biodiversity, other ES such as water purification, aesthetic and recreation value will be considered in subsequent steps. The need for simplification and reliability, along with data scarcity, strongly limits the degree of sophistication and makes it challanging to create a tool, which is accurate and easy-to-use at the same time.

Keywords: Rural Development Programs, Agri- Environment-Climate payments, ecosystem services, livestock, Alpine grassland, decision support system

Introduction

Agri-Environment-Climate payments and ecosystem services

The Rural Development Program (RDP) 2014-2020 commits great attention to the environment, as two out of its six priorities explicitly encompass to the conservation and expansion of environmental quality. Namely, priority 4 concerns restoring and enhancing ecosystems and biodiversity, and priority 5 concerns promoting efficiency in natural resource use. This attention is also promoted by two

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cross-cutting priorities: environment and climate change (European Parliament and Council, 2013).
Other recent policies at European level defined biodiversity conservation and habitat protection as targets, along with the objective of maintaining the delivery of ecosystem services (ES). Specifically, the Biodiversity Strategy (European Parliament, 2012) aims at improving the integration of biodiversity conservation in key sectorial policies, including environment, agriculture, forest and fisheries sectors. The EU Biodiversity Strategy to 2020 requires Member States to map ES in their national territories by 2014 and value them by 2020.
Article 28 of the Regulation of the European Parliament and of the Council on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) refers to Agri- Environment-Climate payments (AEC) as a crucial element of the whole RDP (European Parliament and Council, 2013). Technical guidelines on AEC, defined by the European Commission in May 2013 (European Commission, 2013), represent a useful reference to identify which ES could be relevant. Such guidelines underpin the relevance of the "high nature value farming" for improvements or maintenance of existing favourable practices. Beneficiaries of AEC payments commit themselves to provide environmental benefits (positive externalities). Economic calculation of payments in this case is based on income losses and/or additional costs arising from the new practices. Beneficiaries of maintenance of existing farming practices have to prove that their practices produce environmental benefits and that, otherwise, there would be high probability of abandonment. Environmental benefits clearly refer to ES; consequently, a quantification of the linkage between the farming practice and those ES should be provided.
AEC payments can have different objectives and expected results, distinguishing 'basic' or 'targeted' measures. The former entail minor commitments that can be met by a large number of farmers. The latter are dedicated to particular areas (e.g. particularly rich in plant species) or objectives (e.g. protection of target species) and are expected to provide larger environmental benefits. Understanding of potential ES provision provides sound basis to identify areas suitable for targeted measures. Table 1 summarises general criteria for AEC payments and the contribution of ES-based approach.

Table 1 – AEC payments and ES perspective.

AEC criteria:	ES-based approach:
• presence of vulnerable natural features (e.g. wetlands)	• characterization of areas in terms of ecosystem services (and values)
• types of production with potential negative externalities (e.g. intensive livestock production leading to water pollution)	• identification of positive/negative externalities (in terms of ES loss/gain) associated to production typologies and scenario analysis for management hypotheses
• adjustment to specific local conditions (e.g. species-rich meadows with varied period of mowing)	• identification of optimal production according to maintenance of environmental characteristics (through environmental variables of ES models)
• specific objectives in a particular site (e.g. stop the decline of a certain species, conservation of rich organic soils)	• geographical identification of environmental problems to justify special commitments

The case of alpine livestock farming in the Autonomous Province of Trento (Italy)

The Autonomous Province of Trento, Northern Italy, is characterized by an altitude that ranges from 66 m to 3769 m. The agricultural areas mostly consist of grasslands and pastures (more than 80%) as shown in Figure 1. Livestock farming, mainly represented by dairy cattle, is a traditional source of multifunctional services that range from environmental (e.g. pollination, water flow regulation, conservation of genetic resources, climate regulation) to socio-economic, e.g. use of local forage, presence on and protection of the territory, ecotourism, cultural heritage (Scolozzi et al., 2014).

Like most of mountainous areas, this Alpine area suffers from the abandonment of agriculture in marginal areas and the intensification of farming in the valleys floors (Sturaro et al., 2013). Over the last decades, the number of cattle breeding farms has progressively reduced, along with the increase in farm size (Dipartimento Agricoltura Turismo Commercio e Promozione, 2013); stable-based production is taking the place of traditional summer grazing and foreign cattle breeds are is preferred to local ones. All these developments often promote land abandonment, with negative impacts on multi-functional cultural landscapes (Soane et al., 2012). Thus, the provincial agro-environmental policy and related measures are largely committed to slow down, stop or even reverse such current trends, in particular the abandonment of agricultural land in mountain areas and the intensification of farming practices in valley floors. Besides this, sustainable management practices must be encouraged, with particular respect to fodder quality and fodder self-sufficiency, nutrient balance and effluent management, biodiversity and landscape conservation.

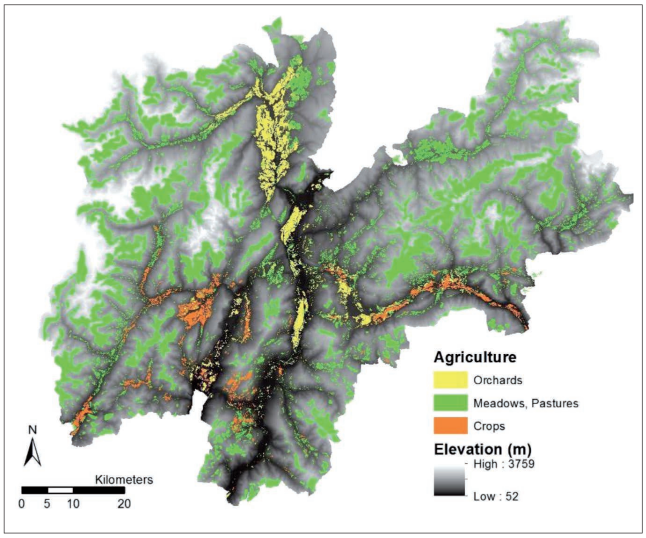

Figure 1. Trento Province and agriculture land covers.

Materials and methods

Preliminary model linking field practices, production and biodiversity values

The definition of the next RDP 2014 2020 explicitly involve the consideration of environmental benefits (or ES) as relevant foundations for decision-making about allocation of payments among farmers. Thus, a preliminary dynamic model is proposed (and still in development), including ecological and management component. Each components reflects a perspective and is characterized by specific variables and objectives. The ecological component comprises environmental variables, such as climate, soil organic content, related to primary productivity. The ecological general objective is the conservation of species richness or target species and habitat (according to Natural 2000 priorities). The management component includes fertilization rate, mowing or cutting regime (number of periodical hay cuttings), and grazing. The related objective is maintaining a good production of forage in terms of quality and quantity. The components are linked by causal relationships, sketched in the diagram of Figure 2. The species richness (or biodiversity values, in case of rare targeted species/habitat) is associated to grassland species association (grassland type), itself related to fertilization. This, required for a profitable hay production, may turn into pressure for low-nutrient tolerant species, negatively affecting the biodiversity values. In the diagram such non-linear relationship between hay quantity and soil organic content is sketched by "s", standing for sigmoidal or bell shape function.

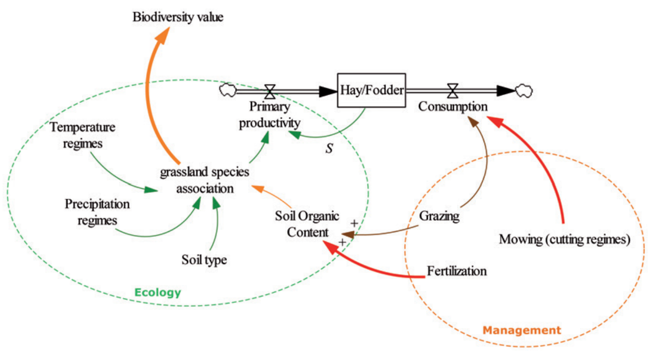

Figure 2. Linkages between ecological and management components.

Management scheme/adapted decision model

Although the model is satisfactory from a theoretical point of view, it shows several problems when used to support management. Botanic classification of meadows, with a comprehensive characterization of terrain morphology, climatic conditions, geological and biological features, and management practices is already available (Scotton et al., 2012). However, this information has a high degree of complexity (44 botanic units and 17 botanic types) for non-experts, and has not been implemented into cartography yet. Causal relationships between field practices and species composition have been widely studied (e.g. Austrheim et al., 1999; Klimek et al., 2007; Lanta et al., 2009; Marini et al., 2008; Rook & Tallowin, 2003; Rudmann-Maurer et al., 2008); but such studies usually concerne limited areas, with numerous monitored variables. It is hardly possible to apply controlled experiments to build impact models for the whole area under the expected management scheme.

For the sake of simplicity and pragmatism, three main categories of meadows have been identified, namely: a) meadows of the valley floors, morainic terraces and plateau, b) slope meadows and c) species rich meadows. Such classification of meadow parcels in macro-zone relies on biophysical conditions, in terms of soil, altitude, biodiversity, beyond the simple relative position in the valley. The species-rich meadows were previously identified through botanic surveys, by local botanists (Scotton et al., 2012). Each zone discriminates actual and desirable management practices (Table 2); this is the main advantage of this classification. The drawback is the static and arbitrary

definition of categories, simplifying the biological components. At this stage of the project, as the focus is set on management variables, rapidly changing ecological dynamics at local (micro) level are disregarded.
The proposed management scheme entails sets of if-then rules, specific for each meadow category, defining the thresholds for field operations and fertilizer (manure) addition to be respected by farmers in order to obtain ES payments (Figure 3a). For species-rich meadows an additional criterion, period of cuttings, concerns the seasonality of target species to be protected. Fertilizer addition is estimated by the number of livestock associated to meadow parcels (i.e. which manure is spread on the parcels), as a proxy of the nitrogen according to literature (Walther et al., 2001). The rules were structured using DEXi program (Bohanec, 2011), but these are still on development. In the Figure 3-b a set of if-then rules is reported, such rules are also named multi attribute decision rules, since they rely on a finite set of qualitative attributes. Each attribute or criterion can refer to either quantitative measurements or qualitative judgments, and it is defined by expert consultation and literature review; in further steps of the project, specific validations and calibrations are planned.

Table 2. Categories of meadows defined for the management scheme.

Meadow category	Criteria for definition ( )	Main risk	AEC payments specific objective	Area (ha)	Mean elevation (m)	Mean distance to farm center (m)
valley floor meadows	• soil type • elevation	intensification	preventing over-use	5530	731	501
slope meadows	• biodiversity • expert judgment	abandonment	maintenance of traditional use	8201	1044	1049
species-rich meadows		biodiversity erosion	conservation of biodiversity value	3616	1289	1571

Table 3. Examples of vegetation habitats included in meadow categories.

Meadow category	Vegetation types (according to Natura 2000)
valley floor meadows	6510 Lowland hay meadows *(Alopecurus pretensis, Saguisorba officinalis)* 6410 *Molinia meadows on chalk and clay (Eu-Molinion)*
slope meadows	6230 *Specie-rich Nardus grassland, on siliceous substrates in mountain areas* 6520 *Mountain hay meadows*
species-rich meadows	6210 *Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (*important orchid sites)*

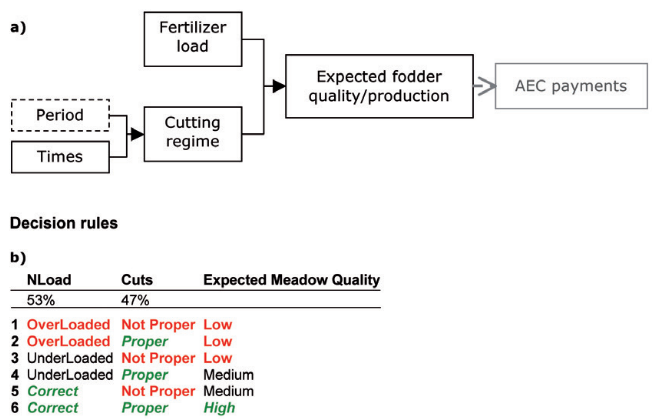

Figure 3. Decision rule scheme (a): each node correspond to if-then rules, specific for each meadow category, in b) a representative rule set is reported (with criteria weight in %).

Results and Discussion

ES-based approach to AEC payments: expected results, limitations and further developments

The simplified approach based on multi-attribute decision rules is expected to support the effective allocation of financial resources on areas and farmers to reach the goals of maintaining the extensive alpine farming and the grassland biodiversity. Even if more sophisticate mechanisms and models could be adopted, already at this stage the decision scheme seems easy to use and easily understandable by agriculture office servants. The transparency of decision rules allows to follow the several steps from raw data (observations, judgments, measurements) to value-based information, this makes the calibration of rules and the incorporation of new data or new data-driven models easier. The current limits concern the need for of reliable definition of rules, testing the effects of rule application and the following payment distribution on the real state of meadows. This will be possible only within adaptive iterations of test and trials.

The traditional landscapes of alpine meadows constitute source for other ecosystem services other than provisioning fodder and supporting biodiversity. The most relevant ES for farmers are: aesthetic values, recreation opportunities, and quality water regulation. The first are linked to the widely increasing nature-based tourism, which may participate to the profits of farmers, the last one is related to potential negative externalities of farming in terms of additional costs for water purification. The field practices may affect such ES in opposite ways; the further steps of payment scheme design will involve such causal relationships to guide farming towards multifunctional landscapes, as required by European directives. Modelling the impacts of field practices on ES provision will require multiple dimensional framing of the ES sources and beneficiaries: ES exist only where someone can benefit from them, thus spatial identification of sources, uses, and detrimental elements is required. Several attempts to measure and model that have been performed and more than a few tools are rapidly evolving. The challenge remains the translation of advanced knowledge into operational tools, as easy as possible to be applied in government and economic contexts.

Conclusions

With the RDP 2014-2020 a strong commitment o environmental issues is expected. The traditional way of programming strategies and (thus) measures, and especially the AEC payments, is no longer viable. An approach based on ES is proposed as supporting tool to justify AEC payments in order to promote sustainable practices as virtuous not only for the directly related provisioning agri-ES but also for other linked regulating and cultural ES.

However, applied research in practice requires to come to a compromise between the scientific complexity and the managerial needs of the public authority for a simple, verifiable and controllable scheme. Our proposal attempts to solve this issue and make the ES-based approach operational in the Trento Alpine area.

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