



Contributions of science to add value to rangeland-based livestock products: the case of Uruguayan ultrafine wool

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Abstract

The conservation of native grasslands implies the safeguard from various threats, such as a change in land use. For achieving the objective native grassland conservation, it is necessary to strengthen extensive livestock systems by sustainability improving their performance and by increasing value of emerging products. We developed a regenerative livestock farming proposal based on research evaluating several environmental aspects of the livestock ecosystem functioning on Pampas biome and production technology developed over decades. The conceptual proposal consists of ten points that consider environmental and socioeconomical aspects. The baseline for environmental indicators includes: estimate of carbon footprint through life cycle assessment; organic carbon stock in the soil; assessment of the ecosystem integrity index (EII); the assemblages of wild birds' communities and the assessment of the genetic level of the flock. The latter is included based on its potential for reducing the greenhouse gases (GHG) emissions by improved genetics. We carried out a pilot project with 15 producers which led to the first "regenerative wool" exports from Uruguay to first world-class fashion brands. The results of the study were: a carbon footprint of 60 kg CO₂ equivalent per kg of greasy wool, 83,5 Mg/ha of soil organic carbon stock, an EII value of 3.5, with a bird richness of 104 and 4.26 of Shannon-Weaver Index. The average potential reduction of GHG emission by genetic improvement ranged from 13 to 18% depending on selection criteria used (improving feed efficiency, increasing wool production or reducing methane emissions). In terms of biodiversity, both the EII results and the richness and diversity of birds are considered very satisfactory. A new collaborative project between INIA and the wool-textile industry seeks to incorporate 110 farmers reaching a total of 200,000 hectares.

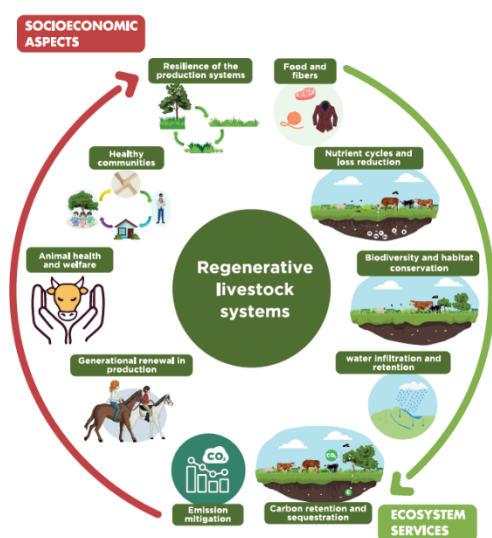
Introduction

The livestock sector in Uruguay is the primary user of native grasslands, which in turn are the dominant ecosystem in the country. The conservation of these ecosystems and the significant ecosystem services they provide depends on preventing their replacement by other land uses and ensuring proper management by farmers. On the other hand, livestock farmers face pressures to maintain the sustainability of their operations, both economically, to sustain or improve profitability and continue land use, and environmentally, to reduce negative environmental externalities. To reconcile both objectives—conservation and economically viable production—it is necessary to

establish a foundational framework: environmental diagnostics based on scientifically robust, multidimensional indicators, in-depth productive diagnostics, a conceptual proposal that allows for the integration of environmental and economic objectives, the appropriate methodology for implementing this proposal in production systems, and mechanisms for the market to recognize the added environmental value and make production economically viable. Our proposal for regenerative livestock farming (Blumetto et al, 2024), was applied in a pilot project with 15 farms and is being applied in a scaling project. This new collaborative project between INIA and the wool-textile industry seeks to incorporate 110 farmers into this productive scheme through a co-innovation initiative that implies a productive and environmental diagnosis of the farms, expanding the influence of this management to 200.000. The conceptual basis and the environmental baseline of the pilot project with commercial stakeholders is described here.

Methods

Conceptual proposal



INIA's proposal, framed in research projects with a co-innovation approach, accompanies the transition towards regenerative livestock farming based on its environmental diagnosis of the farming systems and in agreement with farmers for the productive redesign of the systems. The main objective of the first stage is to implement process technologies and strategic use of inputs, with an adequate native grasslands management (Jaurena et al., 2021), adapting the recommendations for each case and measuring its response in productive and environmental terms. The proposal includes aspects related to soil care and restoration, the care and re-introduction of native tree species, the strategic use of sown pastures and off-farm inputs, and the adaptation of a technological package for animal production. Additionally, INIA carries out the genetic evaluations of sheep and beef, which allows, by using genomics, the identification of animals that are more efficient in feed conversion and with lower methane emissions.

Environmental indicators

A) Life Cycle Analysis (LCA) for greenhouse gases (GHG) emissions

A LCA is carried out to estimate the carbon footprint of the farm system and its supply chain using the methodology proposed by FAO (2017) and the software OpenLCA. In our case, the analysis is carried out from the “cradle” (origin of all inputs) to the gate of the farm (sale of animals or wool). As a result, we obtain emissions of GHG expressed as kg of CO₂ equivalent per kg of co-products and for hectare of production system. The period evaluated is a productive exercise (July 2022-june 2023).

B) Ecosystem Integrity Index (EII)

The index of ecosystem integrity (EII) was applied for each field within the farms (Blumetto et al., 2019). It combines different ecosystem traits assessed by trained operators. Its application involves an assessment of four components: vegetation structure, plant species, soil and watercourses (streams or rivers), obtaining after calculations a value in a scale from 0 to 5, where five is the best possible state (fig 1).

$$IEI = \sum_{n=1}^n \frac{(VE_i + SPp_i + S_i + RZ_i)AP_i}{4RA}$$

Fig 1. Where, VE_i = vegetation structure score for paddock i, SPp_i = species presence score for paddock i, S_i = soil score for paddock i, RZ_i = riparian zone score for paddock i, AP_i = area of paddock, and RA = total ranch area, adapted from (Blumetto et al, 2019).

The EII reflects the distance of the current state of the agroecosystem in relation to the best potential state of the ecosystem in that ecoregion (level 5 of the qualification). The results are calculated globally (the whole farm) but also by paddock or any spatial management unit.

C) Soil carbon stocks

Soil categorization and calculation of organic carbon stock is carried out through a four steps methodology: classification of soils using satellite image classification, field sampling in 30 sites determining bulk density and sending to laboratory for soil organic carbon (SOC) assessment up to a maximum depth of 30 cm, and finally the calculation of the total carbon stock.

D) Associated wild biodiversity

An evaluation of avian assemblage (Gibbons and Gregory, 2006) is carried out, estimating species richness, diversity and priority species for conservation (Soutullo et al., 2013). The study involves bird specialists using the MacKinnon lists methodology (MacKinnon and Phillips, 1993). Although there are numerous groups of wild organisms affected by productive activity, the flora is included within the EII and therefore a fauna indicator is added. The birds were selected for a series of practical advantages: they use all the ecosystems present in the country, they are mainly diurnal and it is possible to identify vocalizations, there are enough specialists to be able to scale the use of the indicator and there is more information available to interpret the results.

E) Productive and environmental genetic level of cattle and sheep

The most relevant rams from each flock (n=10-20) are genotyped, and their genetic value for relevant traits (feed efficiency, wool production, methane emissions, resistance against parasites) is estimated based on predictive genomics. This approach informs farmers about their flock's genetic level and the best options (evaluated rams) to achieve their productive and environmental goals (Vera et al, 2022). To calculate the potential for genetic improvement, a theoretical scenario was proposed where the entire flock of each farmer is replaced by the top 25% of the genetic evaluation. For this, variables that affect emissions were used separately: dry matter intake, metabolizable energy intake and daily methane emission.

Results

Results present the base line including the five indicators for the 15 farms involved in the pilot project.

Greenhouse gases emissions were estimated for a period of one year-round resulting in an average of 2192 ± 351 kg CO₂ eq /ha and the emission intensity for the co-products was 19 ± 6, 13 ± 3 and 60 ± 13 kg CO₂ eq /kg of product for bovine meat, ovine meat and greasy wool respectively.

For sheeps, a simulated scenario where the whole flock of every farmer was substituted by the phenotypically top 25% of animals of the genetic evaluation, produced a reduction of CO₂ eq. emission of 12,8, 17,9 and 13,9 %

considering as the evaluated trait dry matter intake, metabolizable energy intake and daily methane emission, respectively.

The average of global EII for all farms was $3,5 \pm 0,2$. However, analyzing the variability of the values by single paddocks, it increased the SD to 0,6 which implies that exists an heterogeneity in the results considering individual paddocks at each farm. An example for a single farm of geographic representation of IIE and the breakdown of the values obtained for each individual paddock and its components is presented in the fig 2.

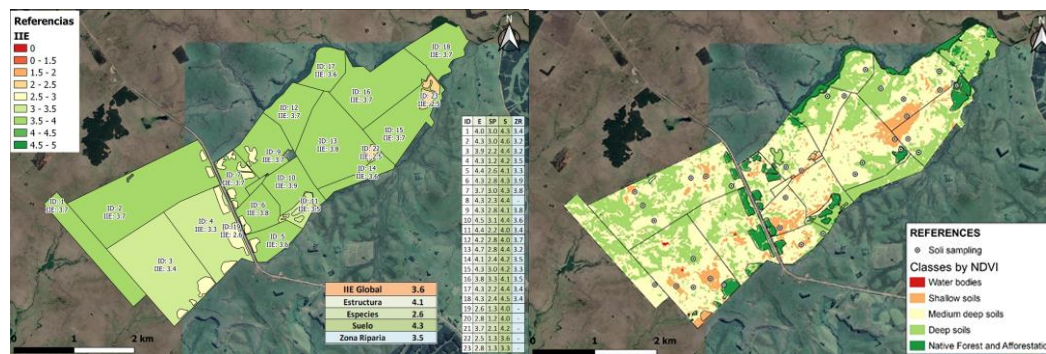


Figure 2 – Example for a farm of spatial representation of EII and the breakdown of the values obtained for each individual paddock and its components (left) and soil categories and soil sampling points (right).

Average soil carbon stock for the involved farms was $83,7 \pm 10,6$ Mg per hectare, ranging between 67 and 94 Mg/ha. The variability is mainly explained by type and depths of soil, mainly in those farms located on the basaltic slope region, which have a high proportion of soils that do not reach 30 cm deep.

In terms of associated wild biodiversity, birds assemblages records results in an average richness of 111 ± 25 and the average Shannon Index was 4.2 ± 0.3 . Additionally 30 species are considered conservation priority for the Uruguayan Environmental Ministry (Soutullo et al., 2014).

Discussion

The environmental results obtained when quantifying the environmental baseline were considered good considering the published references for EII and birds' diversity (De Santiago *et al*, 2022; Aldabe *et al*, 2023) and recently evaluations of 110 CREA federation farmers a of multiple production systems distributed throughout the country (2024, unpublished data). Therefore, it is challenging to propose improvements in these systems. However, there are opportunities for improvement in some aspects. This is only possible with an exhaustive planning such as the one proposed by co-innovation processes. In terms of reducing methane emission intensity, the main strategy is using genetic improvement. Nevertheless, there are improvement opportunities, in some cases, by improving pasture utilization and management, based on increasing forage allowance, allowing food selectivity and therefore improving nutrients acquisition by animals. Carbon stocks are high, near the reported stocking potential (Dondini *et al*, 2023). For this reason, the main objective is to maintain this status, although Piñeiro *et al*. (2024) reported a potential of sequestration of 187 kg of C/year by increasing the net primary production.

EII presented good values in average (de Santiago *et al*, 2022; CREA 2024, unpublished data), but the variability obtained for the different paddocks inside each farm show opportunities of improving through management strategies, specially by improving vegetation structure, reducing erosion predisposing factors and by the protection of riparian zones. This last objective has specific actions through special temporary exclusion of grazing in some streams and riparian zones. The high richness and diversity of bird species make the main objective the preservation of this diversity. Parallely, special management (e.g. pasture mass, conservation of native trees,

streams, rivers and wetlands) will be performed in some areas for improving the habitat for priority conservation species.

The co-innovation process will assure the applicability of environmental measures without compromising the productive results or improving productive and economic outcome. This strategy, based on robust indicators and a medium-term action plan, will allow farmers and industrial processors to access high-value markets for superfine wool.

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