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Editorial

The Challenge of Making the Idea of Sustainable Intensification Operational

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The intensification of agricultural production has become a topic of intense debate in academic and socio-political media worldwide. In southern South America agricultural intensification operates in two ways. On one hand, through the replacement of natural covers (forests and native grasslands dedicated, in general, to livestock) by annual or perennial crops (in general soybeans or pine and eucalyptus plantations). On the other hand, intensification is associated with the increasing input use and/or the implementation of management practices that increase production per area unit.

A key question is whether it is possible to intensify agricultural production in a sustainable way. This question installs the term «Sustainable Intensification» in the discussion (SI), an idea that has a growing presence in scientific literature since 2010, although it had already been used in the 1980s. The SI concept is linked to that of «ecological intensification» (EI), «agroecological intensification» (AEI)[1] and with the idea of eco-efficiency[2]. The definitions associated with these concepts emphasize different aspects, some of them common to all[1]. All cases present the idea of increasing agricultural production while minimizing environmental impacts.

Uruguay has promoted important definitions on the importance of SI as a guiding principle in the definition of policies in the agricultural sector. Through the Ministry of Livestock, Agriculture and Fisheries (MGAP by its Spanish acronym), the concept of SI has been incorporated as one of the six strategic lines of sectoral public policies. The MGAP explicits some of the pillars that should be considered to promote SI: adopt landscape visions, plan landuse and watershed protection, make regulatory adjustments for responsible use of agrochemicals, propose national policies on conservation and use of natural grasslands and native forests, value natural grasslands for their productive attributes and promote good agricultural practices. These pillars are reflected in the consensus reached in global discussion areas [for example, those associated with the *Intergovernmental Platform on Biodiversity and Ecosystem Services* (IPBES)][3] concerning policies and actions that promote a Sustainable Agricultural Intensification. These actions include: promoting specific above and underground diversity, reducing applications of synthetic products,

maintaining or restoring natural or semi-natural areas, promoting habitat diversity, integrating landscape-level practices, preserving soil health, quantifying agricultural productivity and Ecosystem Services on a regular and systematic basis, and facilitate the participation and training of farmers and ranchers. The Environmental Plan for Sustainable Development (EPSD), although it does not expressly use the term SI, incorporates the generation of sustainable productive systems as one of its three dimensions. The recently regulated Agroecology Law (No. 19.717)[4] points in the same direction. In line with this, INIA defined the development of knowledge and technology that supports the SI of agricultural systems as one of its three management objectives[5].

All these political definitions pose a huge challenge to the Science and Technology System: make the idea of SI operational to support decision making and public policies development. This challenge implies quantifying intensification and sustainability. The characterization of an intensification process is not simple since, generally, it is associated not to isolated activities but to an intervention syndrome. Thus, intensifying implies not only replacing a natural grassland with crops, but also applying inputs and using genetically improved materials. Sometimes the intensification is quantified from the interventions (transformation level of natural coverage, application level of agrochemicals, energy subsidies magnitude, etc.), and other times, based on the results (mainly production volumes). The intensification level is also characterized by changes in the agroecosystem as a whole. For example, through the use of indicators that reflect the effect of interventions both in terms of products and in ecosystem functioning. An example of this is the calculation of the Human Appropriation of Net Primary Productivity (HANPP)[6].

Sustainability definitions that are linked to the idea of not compromising the available resources for future generations are conceptually attractive, but virtually impossible to quantify. One possibility to compare the sustainability of two intensification alternatives is to quantify the offer of Ecosystem Services in each of them. For each level of the intensification it is necessary, then, to quantify how the Ecosystem Services (ES) offer changed. To perform these calculations, the systematized information or the conceptual models that allow to compare two intensification scenarios are seldom available. An interesting exception in Uruguay is the quantification of a key ES as is soil conservation. This is regularly characterized by evaluating land management plans. In this case quantification is based on a «production function» adjusted to local conditions and with wide acceptance, such as the Universal Soil Loss Equation (USLE-RUSLE)[7][8]. Land loss indicators have been used successfully to establish a public policy that tends to promote more sustainable practices in soil management under the Law of Soils and Surface Waters Conservation for Agricultural Purposes (No. 15.239)[9].

The Science and Technology System has a huge responsibility in developing indicators of both the ES supply and the intensification level. However, it should be taken into account that indicators, as well as tolerance ranges and actions related to their compliance (incentives, sanctions, etc.), are part of social processes where actors with diverse values, interests and objectives interact. These actors include those who define public policies at national level (ministries involved), international organizations that promote certain practices linked to the SDO (sustainable development objectives), unions, NGO, entrepreneurs and research centers. The level of loss of a regulation ES (for example, water quality or sediment load) that society is willing to tolerate in a given intensification scenario is a political dispute. Working on the technical aspects associated with the development of indicators and impact functions does not ignore the importance of political definitions, but it guides the discussion on rational bases.

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