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# SETTING EFFECTIVE AND FUNCTIONAL, SDG-CONSISTENT, TRANSFORMATIONAL PATHWAYS FOR AGRO-FOOD CHAINS USING A FLEXIBLE MULTI-OBJECTIVE, STAKEHOLDER-PARTICIPATORY BACKCASTING APPROACH

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**Setting effective and functional, SDG-consistent, transformational pathways for agro-food chains using a flexible multi-objective, stakeholder-participatory backcasting approach**

***Abstract.***

*The UN chose Uruguay as first case study for implementing a new set of post-2015 Sustainable Development Goals (SDGs), under the Sustainable Development Solutions Network (SDSN). In 2006, the project issued the first report with the Agricultural Transformation Pathways (ATP) for Uruguay and other two selected study cases: U.K. and China. The methodological approach, inspired in previous work coordinated by SDSN was then used for the first time at country-level, recognizing two main pillars: (1) strong commitment and active participation of key public and private stakeholders; (2) step-by-step "backcasting" method. The objective was achieving three goals: (i) bring knowledge by consulting national experts and practitioners; (ii) foster policy debates on the important issues facing the country; and (iii) generate buy-in among stakeholders to overcome a number of sociological and political roadblocks to transition. The so-called "backcasting" approach for "building a vision of the future we want" denotes a process in which a desired target is set for a future date, and then identifies the best pathway towards achieving that target by moving backward in time. This paper presents useful evidence and learned lessons emerged from the Uruguay case that may help other similar experiences. Relevant details about empirical construction of SDG-consistent ATPs for two contrasting agro-food chains were included in this article: beef and rice. Results demonstrated that setting an effective ATP is a complex task, requiring an important effort of academy and public authorities in creating incentives to bring private stakeholders to a minimum necessary degree of commitment.*

***Key Words.***

Sustainable intensification, SDSN, development, multi-methods approach, public policy

**Setting effective and functional, SDG-consistent, transformational pathways for agro-food chains using a flexible multi-objective, stakeholder-participatory backcasting approach.**

## 1. Introduction

The United Nations (UN) chose Uruguay as the first case study for implementing a new set of post-2015 Sustainable Development Goals (SDGs), under the Sustainable Agriculture & Food Systems (SAFS) thematic network of the Sustainable Development Solutions Network (SDSN). The first study defined under the SDSN initiative focused on beef cattle production systems, given the huge importance of this sector in the Uruguayan economy (SDSN, 2014). However, Uruguay authorities doubled the bet by broadening the scope of the study and extending the efforts of setting up SDGs to other key sectors of its agriculture, such as rice, dairy, rain-fed crops, and forestry.

In 2016, the international team in charge of the initiative issued the first report with the Agricultural Transformation Pathways (ATP) for Uruguay and the other two selected study cases: U.K. and China (Schwoob *et al*., 2016). The methodological approach was inspired in a previous work (DDPP, 2015) coordinated by SDSN and the Institut du Développement Durable et des Relations Internationals (IDDRI).

Used for the first time at country-level, this approach recognized two main pillars, as pointed out by Schwoob *et al*. (2016) and Kanter *et al*. (2016): (i) strong commitment and active participation of key stakeholders from both public and private sectors; (ii) step-by-step "backcasting" method. The first pillar put special emphasis on the participatory building of pathways by stakeholders and experts already involved in the national policy debate. It includes key stakeholders from academic institutions, industry associations, farmer organizations, civil society, and government. The objective is achieving three goals: (i) bring knowledge to the project by consulting national experts and practitioners; (ii) foster policy debates on the important issues facing the country; and (iii) generate buy-in among stakeholders, which is fundamental to overcome a number of sociological and political roadblocks to transition.

The second pillar involves the so-called "backcasting" approach for "building a vision of the future we want" (Schwoob *et al*., 2016). It denotes a process in which a desired target is set for a future date, and then identifies the best pathway towards achieving that target by moving backward in time. A specific challenge when building pathways for the agro-food sector is that sustainable agricultural transformation must take into account and prioritize a raft of targets. Win-win solutions may not exist for some agriculture-related targets, and trade-offs are therefore to be expected. Effective and functional sustainable development pathways for agro-food systems can only result from a political choice concerning these trade-offs and priorities; it needs to be debated and decided at the national or local scale, taking into account the specific conditions of countries and regions.

In this paper, we present useful evidence and learned lessons emerged from the Uruguay case. We focus on the empirical construction of ATPs consistent with the SDGs for two contrasting agro-food chains included in the study: beef and rice. A reduced number of well-organized high-technology farmers and millers comprises Uruguay rice chain. Both parties have a history of integrated work in many aspects of the production system, which made possible developing an ATP without any public intervention. On the other hand, the Uruguayan beef sector includes a large number of cattlemen, slaughter and packing plants lacking any associative culture. Thus, setting an effective ATP was a more complex task, requiring an important effort of academy and public authorities in creating the incentives to bring all private stakeholders to a minimum necessary degree of commitment.

## 2. Background / Theory

### 2.1. Sustainable intensification

In the case of Uruguay, the development of SDGs would focus on the premise of "sustainable intensification" of its agricultural sector, which was defined as a strategic line by national authorities (Rosas and Buonomo, 2016; MGAP, 2016). As a small economy, highly dependent on the export of agricultural products, Uruguay would be able to economically increase the productivity of its agriculture sector in a sustainable way, taking into account the social and environmental dimensions, as key factors.

Under this framework, sustainable intensification was considered as a multi-objective optimization problem: the challenge was maximizing productivity, profits, and social benefits, while minimizing a suite of environmental impacts (greenhouse gas emissions, biodiversity loss, water footprint, nutrient loss etc.). Solving this problem required the adoption of mixed methods, blending modelling efforts with expert judgment from scientists across Uruguay.

The general approach followed in this research is explained in the next section. Roughly, it involved the combination of data from Uruguay's most productive farmers and the use of simulation models to determine the technical feasibility of selected targets for a number of parameters linked to production. Experts from a variety of private and public organizations across Uruguay then brought their judgment on the most ambitious environmental targets and pathways set for the different production sectors in the selected point in future time (based on published literature where possible), given the productivity target and pathways. The selected time frame was the period that goes from 2015 (baseline) to 2030 (target).

### 2.2. The backcasting approach

Robinson (1982) defined backcasting as a method for policy analysis involving "working backwards" from a particular future end-point to the present to determine what policy measures would be required to reach that future. According to this author, the major difference with forecasting techniques is that backcasts are not intended to indicate what the future will likely be, but to indicate the relative implications of different policy goals. In turn, Robèrt *et al*. (2002) pointed out that backcasting is a necessary process to reach sustainability on any system. The starting point of the planning is an envisioned successful future outcome of the planning, that is, a defined future "landing place" on the system level. The strategic paths are then built in accordance with this future outcome since, in words of these authors, having an informed vision of one's goal allows to strategically deal with potential trade-offs from different decisions. While backcasting is a kind of scenario study, not all scenario studies qualify as a backcasting study (Dreborg, 1966). Moreover, Dreborg (1996) argued that backcasting should be seen more as a general approach than a method, as proposed by Robinson (1966).

## 3. Data / Analysis

### 3.1. Applying backcasting under the PIPA framework

In the absence of a methodological of backcasting expressly adapted to a complex sector such as beef cattle (selected as initial system of the global initiative SDSN) the choice of methods and specific tools of analysis and validation was settled through a learning-by-doing process of discussion defined along with the development of the project, sometimes in an *ad-hoc* manner. The same approach, used later with the rice sector, included the learning lessons from the former process as a feedback. Being its structure simpler than that of the beef sector, some of the steps were able to be shortened and simplified.

Figure 1 summarizes the backcasting process adopted in this study, as described by Ferraro and Albicette (2015), under the Participatory Impact Pathways Analysis (PIPA) framework. PIPA is a critical tool that encourage agents to get involved in the whole process, cogitate about its progress, and change the vision to better reflect the needs and learning experiences during the entire period of time. This is a suitable method of planning, monitoring and evaluation developed for complex research projects (Alvarez *et al*., 2010) that emphasizes the inclusion and participation of stakeholders at all stages of the project.

After envisioning the "landing place", that is, setting the goals at time T (2030 in this case), the proper backcasting process starts by defining the intermediate goals at time T – 1, and continues successively with the intermediate goals at T – 2, T – 3, …, and T – k, using the Cause-Effect Model (CEM) described by Kaplan and Norton (2002). This model assumes that the goal defined at time $T - i$ is a consequence of the goal at time $T - i - 1$, for $i = 1, 2, \ldots, k$, and k is a period (one year, in this case) that maintains a causality relationship from the desired future (T) and the baseline (T – k). This strategic map that shows the chronological order of goals and actions to carry out in a relationship of cause and effect that determines the generation of intermediate targets for successive periods T – 1, T – 2, …, T – k, until reaching the goals set at the 2030, starting from the base line of the present.

<FIGURE 1>

However, understanding the passage from goal at time $T - i - 1$, to the goal at $T - i$, requires the identification of a set of actions needed to achieve the new goal. To do this in a sustainable way, it is essential measuring the economic and social effects. In addition, all of the steps and actions must develop in a continuous feedback process. Should an action result in a negative impact (economic, social or environmental), it must be reviewed along with the corresponding intermediate goal, in order to achieve the necessary agreement that ensure positive outcomes.

The analysis of the social factors involved the so-called Outcomes Logical Model (OLM) referred by Álvarez *et al*. (2010). This model links a set of social indicators to key stakeholders to build the commitment and measure the progress of actions and outcomes, ensuring continuity in the whole process. Once the goals are established, the feasible pathways for achieving them are developed through the incorporation of the views of stakeholders and the impact paths drawn in the process. The policy and economics aspects of the process were examined through the Policy Analysis Matrix (PAM) originally designed by Monke and Pearson (1989) and adjusted later on by Lopes *et al*. (2012), with adaptations to the local conditions (Rava, Lanfranco, and Ferraro, 2011; Lanfranco, Ferraro, and Rava, 2018).

3.2. Modelling productive and environmental goals

The selected production systems were the beef cattle sector and the rice sector. While both belong to the top-5 list of Uruguay's most relevant agri-food chains, they exhibit a series of contrasting characteristics that are useful for the purpose of the analysis (Table 1). In both cases, the outcomes of the simulation models were combined with expert consultation and literature review in order to define the final and intermediate goals and their corresponding pathways.

<TABLE 1>

The production targets for the beef sector were determined with the help of an adapted version of the farm-level, herd-based simulation model developed by Soares de Lima (2009). Summarizing the strategy followed in this study, which was described in detail by Kanter *et al*. (2016).

With regard to the rice sector, the potential productive targets were evaluated using the ORYZA V3 model (IRRI, 2015), calibrated and validated for the Uruguayan conditions (Carracelas et al., 2016). The methodological framework used to calculate the set of environmental indicators for both the baseline (2015) and the target (2030) scenarios was developed by Pittelkow *et al*. (2016). A detailed description of the entire process is available through Lanfranco *et al*. (2018). In both cases, the outcomes of the simulation models were combined with expert consultation and literature review in order to define the final and intermediate goals and their corresponding pathways.

## 4. Findings

The general approach followed in this study was flexible enough in order to conduct the construction of feasible sustainable development goals and the corresponding pathways for both beef cattle and rice sectors. The backcasting process carried out under the Participatory Impact Pathways Analysis (PIPA) framework assured the statement of productivity and environmental targets with the participation of the relevant stakeholders.  The simulation results of the sustainable intensification process for beef and rice production are presented in Table 2 and Table 3, respectively.

As suggested by Kanter *et al*. (2016), the development and implementation of the targets and courses of action, case of beef cattle production system, required an important involvement of a range of stakeholders (from farmers and researchers, to government and industry). As shown in Table 1, beef production systems comprise around 45 thousand farms of very different size and technology levels. The high atomization of beef producers distributed over 11.1 million hectares, along with a low level of association, explain the difficulty for engaging actors in SDG and ATP efforts, requiring an important level of incentives from "external agents". The intervention of the public sector for creating the proper conditions and bringing incentives is essential for a real success. In fact, the public sector (Ministry of Agriculture) put in motion, in the case of the beef sector, a variety or policy levers, which are currently at different stages of development (Silva-Carrazzone *et al*., 2016).

On the other hand, the highly organized rice sector is composed by near 550 farmers planting about 160 thousand hectares per year.  More than 90% of the rice growers are unionized in ACA (*Asociación de Cultivadores de Arroz*). They have developed a strong relationship with rice mills, who export more than 90% of the volume produced annually (between 1.2 and 1.4 million metric tons of paddy). Totally dependent on the international market, rice growers use state-of-the-art technology very efficiently. They exhibit a high culture of association that makes relatively easy to engage most of them in SDG and ATP actions, without almost any effort from the public sector (Lanfranco *et al*., 2018).

## 5. Discussion / Conclusions

The Uruguay case study is a remarkable example of United Nations call for implementing the new set of post-2015 SDGs, under the Sustainable Agriculture & Food Systems (SAFS) thematic network of the SDSN initiative. It aims to fulfill several objectives: help individual countries to build, adopt, and implement long-term policies; create a learning platform among policymakers; provide concrete experience on the development of trajectories and on the modalities of implementation of SDGs at national and international scales. The comparison of two contrasting agro-food chains, such as beef and rice is extremely useful to analyze a broad range of situations ought to be encountered in different countries or regions.

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Use any consistent citation style for references (for example APA)

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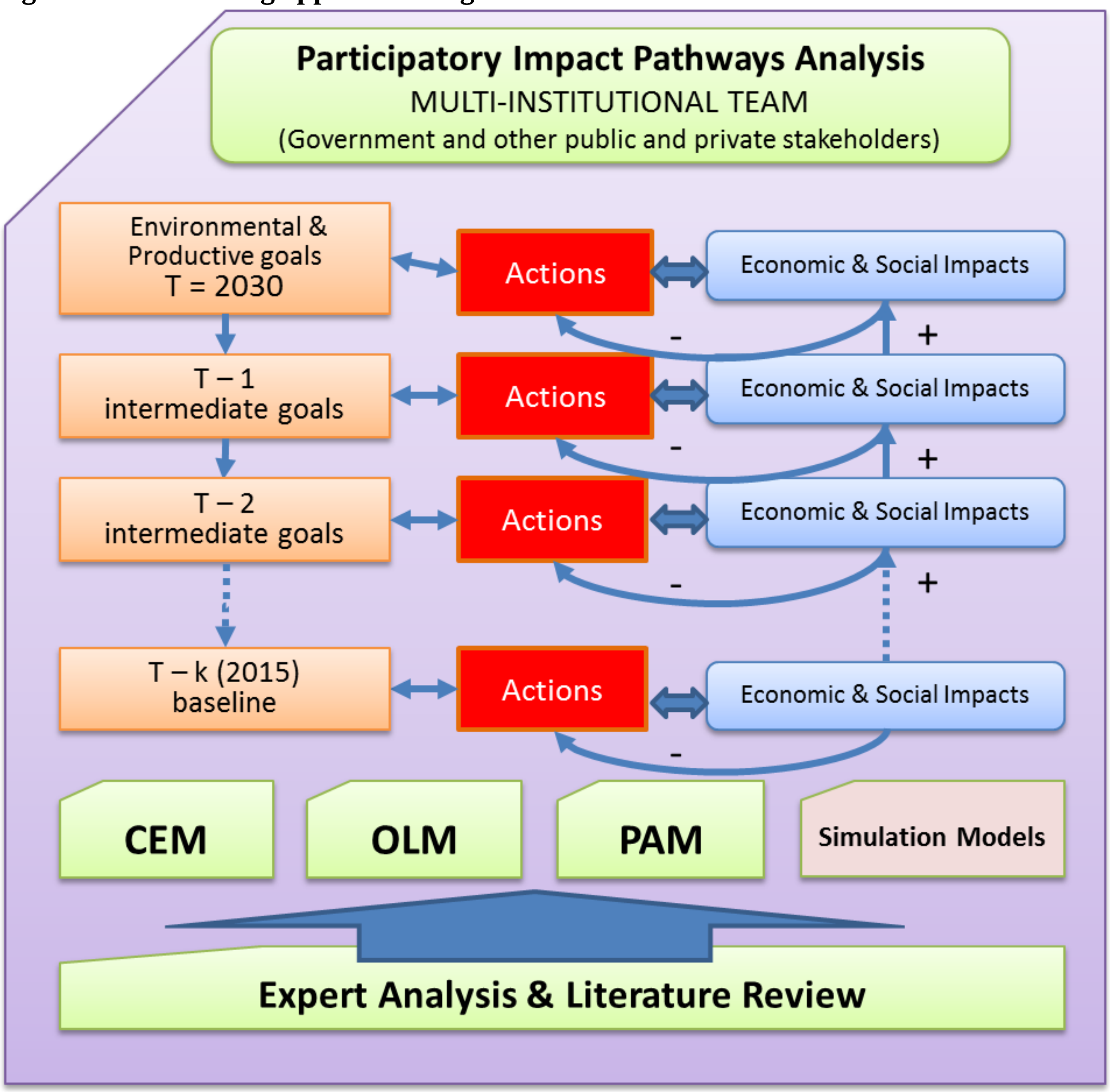
**Appendices**

**Figure 1 - Backcasting approach using the PIPA method**




Source: Adapted from Ferraro and Albicette (2015)

**Table 1 - Characteristics of rice and beef sectors in Uruguay.**

| Sector | Rice | Beef |
|---|---|---|
| Area (thousand hectares) | 160 | 11,100 |
| Number of firms / farmers | 550 | 45,000 |
| Domestic consumption | Not relevant | Very Important |
| Annual per capita consumption | 17 kg | 70 kg |
| Ratio Export / Domestic market | 90:10 | 65:35 |
| Relevance of Exports | Extremely Important | Highly Important |
| Exports, in millions of USD (2018) | 400 | 1.900 |
| Exports as % of total UY exports | 5th position (5.3%) | 1th position (25.0%) |
| Technology Level | **Very High & Homogeneous**: 100% irrigated; 100% certified seeds; few varieties, not blended; no GMOs; low use of pesticides | **High Variability**: +90% grass-fed; open-sky rangelands of native pastures; growth promoters & anabolic banned by law |
| Level of association (farmers) | **Very High**: 95% of rice growers unionized (ACA); very strong relationship between farmers, millers & research (INIA) | **Low**: A number of farmer´s associations and groups with relative representativeness |
| Difficulty to engage actors in SDGs & ATPs efforts | **Relatively Easy**: few very active stakeholders | **Not Easy**: Need to clearly show benefits; need incentives to keep them going |

**Table 2 - Sustainable intensification of beef production in Uruguay, 2015-2030.**

| Variable | Unit | Baseline 2015 | Target 2030 | Change |
|---|---|---|---|---|
| Production (average yield) | kg LW / ha | 102 | 128 | +25.5% |
| Total Slaughter | million heads | 2.4 | 3.0 | +25.5% |
| Breeding Cows | million heads | 4.1 | 4.5 | +9.8% |
| Total Herd | million heads | 11.7 | 11.9 | +1.7% |
| Δ in Exports Money Value | USD / year | 1.57 billion | 2.15 billion | +37.0% |
| Carbon footprint | kg $CO_2$ / kg LW | 20.8 | 15.5 | -25.5% |
| Manure production | tons N / year | 145,850 | 189,210 | +29.8% |
| Nitrate | tons N / year | 41,060 | 38,750 | -5.63% |
| Ammonia | tons N / year | 14,590 | 11,840 | -18.8% |
| Nitrous oxide | tons N / year | 3,520 | 3,630 | +3.1% |
| Total N pollution | tons N / year | 73,750 | 68,810 | -6.7% |
| N pollution per kg of beef | kg N / kg LW | 66 | 48 | -27.3% |
| Δ in Biodiversity (cattle area) | million hectares | 11.1 | 11.1 | 0.0% |

**Table 3 - Sustainable intensification of rice production in Uruguay, 2015-2030.**

| Variable | Unit | Baseline 2015 | Target 2030 | Change |
|---|---|---|---|---|
| Production (average yield) | MT / ha | 8.1 | 9.7 | +19.8% |
| Farm level income | 50-kilo bag / ha | 162 | 194 | +19.8% |
| Farm level costs | 50-kilo bag / ha | 160 | 177 | +10.6% |
| Farm level profits | 50-kilo bag / ha | 2 | 17 | +750% |
| Net energy consumption | Giga Joules / ha | 17 | 18 | +7.0% |
| Net energy yield | Giga Joules / ha | 103 | 119 | +15.2% |
| Total available water productivity | kg grain / $m^3$ water | 0.62 | 0.76 | +22.6% |
| Total emissions | kg $CO_2$ eq. / ha | 7,524 | 7,663 | +1.8% |
| Yield-scaled C footprint | kg $CO_2$ eq. / mg grain | 955 | 790 | -17.3% |
| Total nitrogen use | kg N / ha | 65 | 70 | +8.4% |
| Nitrogen use efficiency | kg grain / kg N applied | 122 | 138 | +13.2% |
| Nitrogen loss | kg N / ha | 31 | 34 | +8.4% |