

RESEARCH ARTICLE

Experimentation in the Design of Public Policies: The Uruguayan Soils Conservation Plans

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Agricultural intensification in Latin America has led to accelerated soil erosion, water pollution and food with pesticide residues, which are all signs of unsustainable development. In Uruguay, agricultural intensification with continuous cropping has threatened the country's primary natural resource: its soil. At the same time, incentives for further intensification and specialization are high, since particularly soybeans have offered the highest (short-term) economic margins. This paper aims to contribute to the discussion about governance for sustainable development through an in-depth critical examination of the main flagship public policy response in Uruguay to soil degradation: *the Soils Use and Management Plans (SUMP)*. SUMP indeed has managed to change cultivation practices in a more sustainable direction. The analysis shows that the relative success of SUMP is partly due to its experimental policy design which has allowed for collective knowledge construction and reflexive learning. It also shows that Uruguay's long history of accumulated domestic soil expertise and state intervention rendered trust in the regulative process among producers and ultimately a high degree of acceptance. Nevertheless, while this policy is found innovative and promising, there is still a need for improvement of governance designs, if genuinely sustainable development is to be achieved.

Keywords: sustainable soil management; sustainable development; public policy; and experimental governance

Introduction

The relationship between modern agricultural production and soil degradation is a topic of growing concern for the governments throughout the region in the wake of the agricultural intensification of the last decades (Bielschowsky 2010; CEPAL, FAO and IICA 2015; Lo Vuolo 2014). Soil degradation is an escalating threat caused by unsustainable land uses and management practices, as well as climate extremes. This problem is extremely relevant for countries which are socioeconomically dependent on their soils. In Uruguay, the agricultural sector represents 12.3% of the country's gross domestic product and agrarian based exports represent 71.4% of the total exports (MVOTMA 2010).

Over the last two decades, the agricultural production in Uruguay has gone through structural changes mainly

explained by commodity prices at record highs, driven by increased demand for food and natural resources from China. Forestry production and agricultural intensification (shifting from 1 crop per year to 1.5 crops per year, and in general to produce more harvest per land unit), including soybean production and especially the introduction of new technological packages, resulted in an acceleration of extractive soil use. The dramatic rise in land prices further increased the incentives for farmers to specialize in a few cash crops, and to intensify land-use, thus losing biodiversity and putting higher pressure on natural resources (Errea et al. 2011; Arbeletche and Gutiérrez 2010, Novelli, Caviglia, and Piñeiro 2017, Oliveira and Hecht 2016). Thus, price relations, in combination with new technologies, made farmers abandon the traditional mixed farming systems and adopt increasingly unsustainable land uses and management practices. These new practices started to threaten the functioning of the soils - the foundation of agricultural development and ecological sustainability in Uruguay.

Against this backdrop, an increasing number of voices within academia, civil society and the state urged for public action to enhance the protection of the soils. However, strict environmental regulation is not easily implemented in the realm of strong private property rights to land. Producers feel entitled to 'do whatever they want on their land' Prohibition and other types of 'Command and

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Control' regulation, are often seen as irreconcilable with strong private property rights, and may face difficulties of effective enforcement. Both domestic politics of most individual states and the international community have shown severe inability to enforce environmental standards for Sustainable management of the world's agricultural soils. At the same time, soil degradation is a real and escalating threat globally. New public approaches to regulate agrarian activities are necessary. It is therefore extremely important to thoroughly investigate relatively successful cases of environmental governance, and to try to learn from them, in order to curb the global threat of degrading soils and in the long-run to ensure global food security.

The aim of this paper is to contribute to the discussion new forms of environmental governance to achieve sustainable development that can deal with complex, interconnected, cross-cutting, uncertain issues and multiple conflicting values, goals and interests from diverse stakeholders. More specifically, it will focus on the leading public regulative response in Uruguay to soil degradation, the soils use and management plans (SUMP), mandatory since 2013. This policy forces all crop producers to engage in land use and management planning, in order to make sure that practices will not result in erosion (over an established tolerated threshold). How did such an interventionist public measure gain acceptance among farmers in the midst of strong market pressures for crop specialization and intensification? This paper makes an in-depth analysis of the policy design, including stakeholder participation and collective learning, as well as historically formed domestic conditions regarding soil conservation and regulation. From a nuanced discussion about the strengths and limitations of this environmental public policy, important lessons can be drawn that may play a role in tackling the worldwide challenge of escalating soil degradation in the face of the well-known difficulties in implementing and enforcing environmental regulations.

The paper is set out as follows: First, we introduce the theoretical framework and the research methodology. Second, we describe the most relevant transformations in the agricultural sector in Uruguay in order to have a systemic perspective. The third section focuses on the cultural-historical process of the soil conservation policy. Then we present the analysis of the process of policy design of the SUMP and the emergent patterns of innovation. The paper concludes with a discussion about the challenges in governance systems regarding complex sustainability problems.

Experimentalist Governance

This research is inspired by the recent approaches of experimentation in public policy, emerging as a response to the recognized widespread policy failure to enforce environmental standards for Sustainable management. Governments are using a wide range of experimental methodologies as an important strategy to address environmental challenges and construct solutions in times of uncertainty and divergent interests (Laakso, Berg and Annala 2017;

Ansell and Bartenberger 2016, Voß and Schroth 2018; Jordan et al. 2018; McFadgen and Huitema 2018).

Building on the philosophy of pragmatism (Dewey 1911; Schön 1983; Ansell and Barterberger 2016) identify three basic logics of experimentation in the public sector: 1) Controlled experimentation: aims at discerning causal effects, controlling different factors that may influence experimental outcomes and isolating causality so as to deductively prove or disprove hypotheses. 2) Darwinian experimentation: aims at increasing systemic innovation and increasing variation in order to inductively produce innovations or benchmarks. 3) Generative experimentation: based on a pragmatic approach (Ansell and Bartenberger 2017; Popa, Mathieu and Dedeurwaerdere 2015), aims at developing a process of generating and iteratively refining a solution concept (an idea, innovation, design, policy, program, etc.) through continuous feedback. It addresses a particular problem by refining and redefining it in order to abductively generate solutions. Generative experiments seek to stimulate production and analysis of information about intervention in order 'to help re-specify and re-calibrate it until it works' (Stoker and John 2009: 358 cited by Ansell and Bartenberger 2016: 68).

Pragmatic culture goes beyond the positivistic vision (rationality, reductionism, predictability, determinism) and reflects 'in' and 'on' practice. In policy design, it implies an open-ended inquiry that conceives research as a collaborative process of problem solving based on deliberation, experimentation, learning and context specificity in which actors are led to question and jointly reframe their values and understanding, in other words, a trans-disciplinary co-production of knowledge (by scientific and extra-scientific actors).

The process of policy design is continually updated and adjusted, and each action is seen as an opportunity to learn more about how to adapt to changing circumstances. Public policies become hypotheses, and management actions become experiments to test those hypotheses (testing in the action process itself) (Folke et al. 2005). The iterative updates associated with the generative experiments involve a constant negotiation to move towards a solution that satisfies the different stakeholders. It is unlikely that a generative experiment will advance without a certain degree of shared agreement of the problem itself and the desirability of learning about it. Bos, Brown and Farrelly (2013) argue that a shared learning agenda is an essential starting point for a public policy experiment.

Under this lens, public policies are seen as learning experiments that need to be monitored, evaluated, and adapted over time. Thus, the process of public policy design is not divided into stages, it is designed and then implemented, although it is continually updated and adjusted. Each management action is seen as an opportunity to learn more about how to adapt and adapt to the circumstances by changing and combining the characteristics of dynamic learning and collaborative management.

Experimentalism is, therefore, a process of iterative adaptation to new circumstances and experiences that entails a

certain idea of progress and improvement but no teleological endpoint. A key feature of generative experimentation is that it leads to an appreciation for path-dependence, and to a conception of growth as a continuous reconstruction of experience (Dewey 1938; Koopman 2011). Generative experiments, therefore, exhibit strong historicity. As Pohl and Hirsch Hadorn (2007) note: 'Recursiveness (or iteration) implies foreseeing that project steps may be repeated several times in case of need' (2007, 22). Given this iterative adaptation through time, a generative experiment cannot be understood as a single and discrete 'trial' (Ansell and Bartenberger 2016).

Research methodology

The study of SUMP was based on a qualitative methodology using the case study method (Yin 2003). The case – SUMP – was selected on the basis of its flagship status; it is often stressed as the most important public policy regarding environmental regulation by the policymakers themselves (Hill, Mondelli and Carrazzone 2014; MGAP-OPYPA 2013; Hill and Clerici 2013). The research conducted was guided by the following leading questions: Which emergent patterns in the policy design of SUMP can be identified as innovative in overcoming hierarchical decision-making? What role did the previous public policies addressing soil erosion and protection play in enabling the emergence of the new model of soil governance? What are the challenges for an emergent type of public governance in the Uruguayan scenario?

The research followed a two-step qualitative design framed within the interpretative paradigm of policy analysis. The techniques used entailed document analysis, participant observation and 15 in-depth interviews conducted between November 2016 and March and April 2017. The research was conducted in an iterative-cyclic process. We collected the documents (legislation, technical reports, ministerial decisions), conducted interviews and observations while simultaneously triangulating these with scientific and gray literature, which brought different perspectives to the analysis.

The first phase of the research process was focused on the historical analysis of the political, economic and productive transformations that paved the way to the implementation of this public policy in 2013. Knowledge accumulation, institutional practices and collective norms are historically formed and slowly evolve; and new regulatory frameworks build on regulations. Accordingly, this study explored the historical background and institutional narratives built around soil erosion.

The second phase focused on exploring the process of design of SUMP which became a tipping point from a previous public impetus for soil conservation led by Investment and Economic Development Commission (CIDE)¹ characterized by top-down and technocratic policymaking. The new policy introduced an experimental, reflexive, co-produce and adaptive approach of policymaking (potentially contributing to the relative failure in the implementation of the former and the relative success of the latter).

The recent agrarian transformation in Uruguay

The three major agrarian transformations in Uruguay during the last two decades are linked to the forestry complex (afforestation and cellulose complex), the 'boom' of oilseeds and cereals (led by soybean expansion and double-cropping with mainly wheat) and the intensification and higher quality production of beef. Correspondingly, beef, cellulose and soybeans are Uruguay's three top export items, and for all three of them China is by far the most important buyer. In 2016, 73% of Uruguayan soybeans, 37% of its cellulose, and 35% of its beef was destined to China (Uruguay XXI 2017: 4). These commodities are interlinked, in which increased competition for land has increased pressures towards intensification of land-use.

The forestry expansion in the country is clearly the result of well-known public efforts to attract foreign forest and timber companies to invest in Uruguay, institutionalized in the Afforestation Promotion Law in December 1987 (No. 15,939), which granted tax exemptions and subsidized forestry plantations. Public policies have also been important to increase the quality and international competitiveness of beef (traceability, programs for access to high quality, high value, markets, free from food and mouth disease, etc.). However, the rapid crop expansion in Uruguay was not the result of any intentional public policy. Quite the opposite, the Uruguayan state was 'taken by surprise' by the rapid soybean expansion, which was described to be the result of mainly exogenous drivers, according to interviews with both business and public actors.

The main narrative of the crop expansion: When international prices of soybeans started to increase in the early years of the new millennium, big 'foreign' (mostly Argentinean) crop producing firms came to Uruguay, attracted by its relatively low land prices. These new actors brought a new technological package centered in herbicide tolerant seeds, glyphosate and no-tillage, which allowed intensification (double-cropping) and continuous cropping systems (marking a break with the traditional crop-pasture rotation system), as well as an organizational model centered in sub-contracts, extensive use of information technology and geographical diversification as a risk management strategy, involving important economies of scale. The cultivations rapidly created an important exportable surplus, which in turn attracted multinational brokers (traders) who took the cargo to the final destination, mainly China.

All previous expansions of cropland over livestock land had historically been the result of proactive public policy, and hence business actors often make a strong point on the fact that the soybean expansion is the first time in history that crops expanded over pastures based on its 'real' value, i.e. market value. While the crop expansion was clearly not the result of intentional public policy, it is nevertheless clear that public regulations were decisive for allowing the crop 'boom' to occur in Uruguay.

When the soybean expansion started, in 2002/2003, liberalization and deregulation reforms had already been high on the agenda of the subsequent 'Washington

Consensus' that inspired Uruguayan governments for decades (Paolino, Pittaluga and Mondelli 2014, Arbeletche and Carballo 2006). Some concrete examples of particular relevance for the 'soya boom' were the authorization of genetically modified (GM) soybean seeds (HT 40-3-2-) in 1996; the modification of the land Leasing Law that deregulated contracts in order to encourage short-term leases which would later be used by soybean investors; the new legislation from 1987 that sanctioned free trade zones, the Investment and Promotion Law (No. 16,906) of 1996 that favoured foreign investments of all kinds, lifting legal obstacles in the agroindustry sector, among others, and finally, the *de facto* devaluation of the Uruguayan peso after the banking crises in 2002, benefitting all export-oriented sectors. While this intensification of production deepened the erosion of soils, Uruguay has a long history of both soil degradation, and public responses aiming to overcome the problem. This history provides an important backdrop as the contemporary plans build on accumulated knowledge from previous experiences.

Soil use and management plans: a brief description

In this context of dramatic transformations, one of the most important advances in agricultural policy regarding the protection and conservation of soils has been the implementation since 2013 of the Soil Use and Management Plans (SUMP) for croplands by the RENARE at the Ministry of Livestock, Agriculture and Fisheries (MGAP, its acronym in Spanish). The objective of SUMP policy is to reduce soil erosion caused by hydric factors, which is the main environmental problem associated with agricultural farmlands in Uruguay. In this way, the country moves towards fully implementing, for the first time, the Law on the Use and Conservation of Soils and Water (Law No. 15,239 from 1981), regulated by Decree 333/004 of September 16, 2004, which in turn has been modified by Decree 405/008 of August 21, 2008 and complemented by Law No. 18,564, of September 11, 2009.

These regulations determine that: 1) The responsible for the management of the land is the landlord (even in case of rented fields); 2) Each landlord has to submit a plan of land use and management to the MGAP; 3) The plan has to be signed by an agricultural engineer; 4) Those who do not respect the law are subjected to sanctions: the payment of a fine and the suspension of the license to practice agriculture.

The SUMP is a declaration of a projected production system, on which the erosion is modelled. The rule is that erosion must be kept below a maximum value of tolerance according to the conditions of the soil where the plot of agricultural land is located. According to RENARE, the soil loss rate has to be lower than 7 ton/ha/year (soil erosion tolerance). To estimate the tolerated erosion for each plan the universal soil loss equation (USLE) is used (Wischmeier and Smith 1960), its revised version (RUSLE) (Renard et al. 1991) and the open software Erosion 6.0.20 developed in Uruguay (García Préchac et al. 2009). In addition, the policy stipulates rotation and other management practices must be adopted.

Before the SUMP became mandatory in 2013, the policy went through a pilot phase, between 2010–2012, engaging a small group of volunteer farmers who were owners or tenants of croplands. During the pilot phase, several activities were promoted, including more than 100 workshops with farmers and agronomists to discuss the new instrument. Two types of workshops were held. One type corresponded to instances of dissemination, training, and discussion about the implementation of SUMP with producers. The other type of was focused on the training of the external technicians, responsible for submitting the plans. In the workshops run by the Ministry, it was discussed how to carry out land mapping, how to build capacities with the different mapping units, propose the estimation of the loss of soil erosion and select the production system to avoid soil erosion.

In regards to the technical training and accreditation to elaborate and submit a plan, the MGAP promoted an agreement between the Faculty of Agronomy and the Uruguayan Association of Agronomists (AIA), for the implementation of the accreditation system and to standardize the quality of the contents included in the plans.

By the end of the pilot phase, thirty plans were submitted: thirteen in the department of Soriano, four in Colonia, two in San José, Rivera, Flores and Paysandú, and one in Rocha, Río Negro, Tacuarembó, Durazno and Cerro Largo. The thirty plans cover a total area of 29,103 hectares, of which 22,333 are agricultural land. In addition, land tenure was detailed: 53% owners, 41% tenants and 6% in a situation of mediation. Moreover, 65% of the agricultural area has pure agricultural rotations, while 35% has rotations with pastures.

In the winter of 2013, the SUMP became compulsory for landowners and land tenants planting more than 100 hectares of wheat and barley. It was extended to sorghum, corn, soybean and sunflower in the summer of 2013–2014. After three years of testing and adapting the instrument with all the stakeholders, the pilot plan was scaled up, and the soil use and management plans became a requirement for all farmers cultivating over 50 ha of land.

According to MGAP's last released report on SUMP, up to February 2019, a total of 16,121 plans were submitted corresponding to an area of more than 1.6 million ha of cropped lands. There was barely a 4% non-compliance and a minimum percentage of omission (MGAP-DGRN 2016). So, how can this relative success be explained? This research has identified three main factors: 1) Historically formed knowledge traditions and a strong legal framework establishing soil conservation as a public concern. 2) A relative high degree of experimentation and participation in the public policy design. 3) Transdisciplinarity and collaborative elements.

The historical and cultural process towards the implementation of the use, conservation and soil management plans

While the recently implemented soil use and management plans constitute an innovative approach, in specific response to the recent process of agricultural intensification, it is important to underline that they did not emerge

in a historical vacuum. Quite the opposite, both the belief in strong 'rational' scientific planning and the concerns over soil degradation and erosion have been around for a long time in the Uruguayan agricultural history.

Since the consolidation of the modern independent Uruguay state, two rather contradictory traditions have lived side by side and been remarkably stable over time. One is the agrarian tradition characterized by land concentration, low technology use and risk aversion (Barrán and Nahum 1984: 656). The Uruguayan land was dominated by extensive livestock raising on natural pastures while annual cropping was produced on small parcels in the vicinity of cities by dirt farmers. Both ranching and cultivations produced on average relatively low and variable yields, or heads per hectare. The poor performance was due to low use of technology, inadequate soil and water conservation practices, and high climate variability (Ernst and Siri-Prieto 2011: 153). While both overgrazing and continuous tilling damaged the soils and caused degradation of the soils, the most severe erosion emerged in the systems of annual cropping (Bertino and Bucheli 2000: 8). The damage caused by continuous tillage made crop producers gradually move from the vicinity of Montevideo to the fertile soils along the Western littoral in the 1930s and 40s (Bertino and Bucheli 2000: 8).

The other tradition, equally characteristic of Uruguay, is a predominantly 'rationalist' and strong belief in progress, reason and scientific planning, as opposed to policies based on interest (Garcé 2002: 26). The economic historian, Henry Finch, describes how Uruguay for the most part was governed by politicians and bureaucrats that did not necessarily represent the interests of the agrarian (livestock) activities, on which most of the economy depended, but articulated a proper rationalist public policy discourse.

From time to time, throughout the 20th century, the rationalist tradition attempted to invoke changes in the agrarian tradition. Law proposals, agrarian censuses, new research institutes, etc., were launched in order to transform the agrarian system into higher productivity, more use of technology, more crop production and the subdivision of land (Baráibar Norberg 2014: 135). Some policies managed to bring about some intended changes. The crop area for example expanded significantly, as well as the number of family producers, due to governmental effort to bring about national self-sufficiency (Griffin 1974: 20). Overall, however, the agrarian system was continuously concentrated, technological backward and risk averse. The powerful ranchers' organizations resisted many of the politically proposed changes, and the state recurrently lacked economic resources for reform implementation (Barrán and Nahum 1984).

Regarding the soils, concerns over increasingly degraded soils grew stronger in the 1930-40s, resulting in some initiatives and public support for the construction of terraces to cope with erosion and surface runoff (Petraglia et al. 1982).² However, Uruguay lacked deep site-specific knowledge about its soils. A nation-wide survey of the soils was deemed necessary in order to develop the crop sector in the country. This was discussed for many years, but finally

within the realm of the most ambitious research and planning effort in Uruguayan history, the *Commission of Investments and Economic Development* (CIDE) was created. At the core of the CIDE project, partly funded by the 'Alliance for Progress', launched by John F. Kennedy in 1961, was the coordination of public sector investment projects, and a clear commitment to develop the agricultural sector. This included agrarian reform through the gradual redistribution of land, but also measures to strengthen competitiveness, overcome technological backwardness and increase productivity. For this purpose, a range of reform proposals were launched, including more resources for agricultural research and extension, and a tax reform that would create strong economic incentives for landowners to incorporate more technology and increase productivity, and sanction low productivity on potentially high-yielding land (Garcé 2002: 66–67).

One of the offices created within this framework was the office called *National Commission for Agro-economic Land Research* (CONEAT). Its main objective was to provide the necessary information of all national soils to be able to design a land tax system offering economic incentives for productivity increase and to avert land speculation. Such a tax system required previous knowledge about the productivity potential of the soils in each plot. Accordingly, the commission worked for ten years with the training of specialists and with data collection, using both aerial photography and field studies. An extensive mapping and measuring of the soils of each parcel of land laid the basis for the development of criteria for the definition of the productivity of each parcel of land of Uruguay (based on the annual potential production of beef and wool). The commission created an index, CONEAT (named after the office who created it), which effectively communicated the average productivity of the soils within one parcel of land.

Many previous rationalist attempts to change the agrarian tradition, most proposals from CIDE were never fully implemented. Strong regulations were perceived as threatening to strong private property right to land. Moreover, as the country suffered a military dictatorship followed by a wave of neoliberalism, the work of CIDE was in large 'forgotten' for decades as the state took a step back from agrarian development planning (technician interview).

Nevertheless, the information gathered by CONEAT and the creation of the index still had long-lasting effects. One of the most important effects may have been that it increased the understanding of the serious situation of the Uruguayan soils quality, in which most of the cropland suffered from erosion. This new empirically based understanding of the alarming rates of erosion, threatening the natural resource dependent economy as a whole, became an important point of reference for advancing conservationist regulation. This was clearly reflected in the 1968 Law on the Use and Conservation of Soils and Water (No. 13,667), in which soil conservation was declared national interest. The law stipulated fines for those producers who did not take action to conserve the water and soils, and established that the National Republic Bank (BROU) should prioritize soil and water conservation. However,

the technicians working at CONEAT saw that the law was not enough for achieving a regulation of land-use, and it was not fully implemented (Interview with Ruben Puentes, Punta del Este, 11 March 2017).

Therefore, they contacted the board of BROU directly and managed to convince the bank to require that all producers take conservation measures in order to receive any line of credit. The impact was huge, at least for 3-4 years, but the conditionality stopped when the bank changed its board. The unsustainable practices immediately returned and so did erosion.

CONEAT also rendered an important arena of interaction and collaborative learning between technicians and producers, because of the many field visits and recurrent talks. In addition, the index became one of the most important land-use decision tools for farmers as well as for the state in the context of spatial planning. The accumulated knowledge about erosion created within the realm of CIDE may also have influenced the rapid adoption among farmers of the mixed pasture-crop system during the 1960s and 1970s. By integrating crops with pastures, the problems caused by over-grazing or continuous cultivations could be solved and productivity was boosted. The mixed system can also represent a case of collective knowledge creation and diffusion, since researchers and producers worked closely together in concrete and yet experimental ways, in which the system was designed and spread.

While the conclusions from CONEAT were not fully implemented in public policies, some of its recommendations were nevertheless, as mentioned, incorporated in the 1968 Law on the Use and Conservation of Soils and Water (No. 13,667), later updated in 1981 (No. 15,239). This legislation currently provides the state with the right to override the interest of landowners and force them to adopt land-use and management practices that prevent soil erosion and degradation. In this way, the state was provided with strong legal tools to ensure sustainable land use and management (Baraibar 2019). In the practice, however, it was never put into force; there were no inspection team, no fines, and no clear measurements or thresholds regarding soil quality for producers to follow. Until recently, when the soybean expansion in the new millennium came to break the mixed model of crop-pasture rotations in the Littoral and a new wave of continuous cropping emerged. While continuous cropping, this time, was under no-till farming, with well-known conservation benefits, it soon stood clear that no tillage was enough to preserve the quality of the soils. Thus, concerns over erosion returned to the public policy agenda (García-Préchat et al. 2004). SUMP emerged in an effort to meet these concerns, and in an effort to finally implement the 1981 Law on the Use and Conservation of Soils and Water.

Emerging patterns of experimentation in public policy

The concept of experimentalism, as emerged from the data, relates to two interlinked components of the process of policy design: the concepts and ideas that were refined during the pilot phase (2010-2012) and the collaborative

work of *learning by doing* between government, producers, and external experts implementing the online platform (2013–2017).

The plans which are a technical standard for monitoring the land use were initially developed by RENARE in collaboration with the Faculty of Agronomy (FAGRO) and the National Institute of Agronomic Research (INIA). An external Technical Committee was set up with representatives from RENARE, INIA, and FAGRO to advise on the policy design process.

Moreover, during the pilot project (2010–2012), policymakers worked with producers, external experts, and associations of producers to plan the best productive use of soil based on an erosion estimation protocol with determined tolerance thresholds. Producers played a critical role in testing and detecting problems in applying the Revised Universal Soil Loss Equation (RUSLE) with real values and on a sufficient scale to obtain the erosion levels that each soil type could endure.

The associations of producers played a critical role in expanding information and knowledge amongst their members and improving the application of the SUMP. The most relevant associations involved were the Rural Association of Soriano (ARS), the Uruguayan Association of Direct Sowing (AUSDI), the Federal Agricultural Cooperatives (CAF), the National Agrarian Cooperative (COPAGRAN), and the Uruguayan Federation of CREA Groups (FUCREA). In the past, these associations had already expressed their concerns regarding the high levels of soil erosion as a result of changes in soil use, particularly with the increase of soy sowing. The growing demand for land from Argentinian producers to plant soy continuously altered a culture of rotation that existed amongst local producers. Thus, the initiative was well received amongst members of these associations who were already familiar with rotation.

To engage the private sector in the pilot, the MGAP launched an open call for producers to sign up voluntarily in 2010. As a result, twenty-four companies were recruited to elaborate their plans with the assistance of experts from RENARE. From May to September 2011, the technical team from RENARE reviewed the first submitted plans followed by several feedback workshops with the voluntary companies. This iterative process between the group of experts from the government and the volunteering producers as well as with external agronomists allowed the adjustment and validation of the methodology.

The construction of the online platform to submit the plans was also an experimentation process which lasted five years (2013–2017). In 2013, a 'very precarious' platform was available, as an agronomist involved in the process states. In this platform, the certified agronomist uploaded the general information of the agricultural land, a file with the geographical information (defined by Google Earth or other similar programs) and an estimation of the soil erosion calculated by the open software (Erosion 6.0.20).

During 2014 and 2015, the RENARE worked with the Ministry's IT technicians and a software development company to make the online platform more precise with

the addition of a geographical viewer that enabled to draw the agricultural lands in real-time. The improved version of the software posed a relevant problem to migrate information from the original tool to the new one. Consequently, RENARE interacted permanently with external technicians, who provided information about errors and usability of the platform. During this process, technicians from RENARE tested the analytical tools to assess the plans and the emerging obstacles.

Nevertheless, this second version of the software was not efficient, 'The platform was improved, but it was not enough [...] the model was still being calculated by the desktop version software and then uploaded to the platform' (technician from RENARE). Thus, a third stage to improve the software took place (2016–2017). Now it was decided the development of an entirely new platform. Following a public tender request, a national consortium was created (Geocom and Discent). The consortium built the first prototype in collaboration with RENARE, which was discussed with the certified agronomists who validated it after their observations were incorporated. Then, continuous tests were done with RENARE technicians until it became operational. The final version of the software was approved by the Technical Committee.

With the new platform, the plans were submitted online using Erosion 6.0 (free software) and were controlled and monitored through satellite images. In this way, the computer system and satellite images served to analyze the basic information of the submitted plans allowing the government to oversee their implementation. In particular, the system could identify locations at a higher risk of erosion as well as locate farmers who were not complying with the crop rotation plans that they had submitted (technician interview).

In synthesis, the concept of experimentation from a public policy perspective differs from the traditional positivist approach, and it refers essentially to a process of learning by doing in which new approaches are discussed with networks of actors to deal with the different aspects concerning challenging public problems. Experimentalism in this context, presents a new form of steering that diverges from conventional hierarchical governance, the New Public Management (NPM), or from the bottom up, as in devolved or 'interactive' 'network' governance. This framework may help to deal with disputed, value-led environmental policy issues and different scientific foundation to solve the problem. In the SUMP experimentalism emerged during the pilot phase and the development of the online platform.

Emerging transdisciplinarity

As it has been described above, experimentalism in this policy context is essentially transdisciplinary because it involved the collaborative work of different actors to adjust and validate the methodology in SUMP and the online platform.

The design of the policy and the metric definition to evaluate sustainable rates of soil erosion (USLE) and its revised version (RUSLE) were the result of a process in which the government and the academic sector worked

together. In the science-policy interface, it is imperative to highlight that the scientists who developed the model are those who held the positions of Directors of RENARE when the policy was designed and implemented. As an academic involved in the process states: 'The most relevant decisions regarding the measurement of soil erosion are made by the Committee formed by the MGAP, the Faculty of Agronomy, INIA and Uruguayan Soil Science Society (USSS)'.

The pilot process of designing the plans shows how scientific and non-scientific bodies of knowledge were integrated to support concrete problem-solving efforts (Pohl et al. 2007, Hirsch 2008). This refers to the purpose of reflection-in-action, as opposed to rational problem solving (Schön 1983). As Popa (2015) argues during the 1980s and 1990s mainstream interdisciplinarity emphasized the articulation of disciplines into 'coherent frameworks' while new insights of transdisciplinarity have shifted the focus towards the extended co-production of knowledge (by scientific and extra-scientific actors) and the importance of 'unsettling' established assumptions. Consequently, even though it is based on collaborative problem solving, scientific and technical knowledge are seen as the core element in informing and guiding policymaking and social action.

The revised experience leads us to take into account the relevance of transdisciplinary knowledge networks between policymakers, academia and producers to achieve a common vision-action to tackle soil erosion in Uruguay. This implied generating knowledge through a process of plural stakeholders' reflection and improving the anticipatory capacity in policy design to incorporate uncertainty and identify the consequences of possible solutions, 'The basic premise was to make a collective construction with all sectors involved [...]. Today, a policy is based on science and more science is demanded to make policy. An inter-institutional synergy is required' (Government official).

The learning process involves the exploration and integration of useful knowledge, whether tacit or codified, for a deeper understanding of a problem and, therefore, better decision-making (Poteete et al. 2010) and transformation (Westberg and Polk 2016). The most relevant conceptual basis for transdisciplinarity is the systemic vision of the problem as a social construction process and learning in action (Hirsch Hadorn, Pohl and Bammer 2010) as two inseparable and simultaneous acts (Westberg and Polk 2016). As a producer observes, 'The virtue of the Use and Management Plans (SUMP) is to have the issue of soil conservation on the table. Of all that is done, I think a great improvement is to avoid soybean monoculture, and soil-coverage is interspersed'.

In this context, the reflexive participation mobilized public support enhancing public trust in scientific expertise and intervention that allowed better management of value differences and conflicts and facilitated convergence on preferable solutions rather than searching for elusive 'perfect' solutions built on a normative vision to guide social change. As a government official stated 'Progress is not only creating normative rules (laws, regulations) but also including cognitive or interpretative regulations related to how people become aware of the issue of soil

erosion and their views about the problems that guide their behavior and actions'.

A generative experimentation strengthens the dialogue between science with political and social definitions. In this process, science and technology played an important role in the development of land loss indicators. This has allowed the establishment of a public policy that promotes more sustainable practices in soil management, which is a regional and international reference (Tiempo Agrario 2015; FAO 2019). However, it should be borne in mind that the importance attached to the indicators, as well as the ranges of tolerance and the actions linked to their compliance or non-compliance (e.g., incentives, sanctions, etc.) are part of social processes in which actors with diverse values, interests and objectives interact. The level of loss of an ecosystem regulation service (for example, water quality or sediment load) that society is willing to tolerate in the face of increased productivity is a political dispute. Solving 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 a rational basis (Paruelo 2016).

Past-present-future triangulation

In the past 50 years, Uruguay has collected a vast amount of soil data to adapt the Universal Soil Loss Equation to a national scale. Soil Use and Management Plans have integrated current knowledge in soil management science with the rich data available in Uruguay to address erosion and the protection of soils.

The problem regarding soil erosion in Uruguay was framed in the triangulation of past, present and future by asking what was possible in the present using what was learnt in the past aiming to be productive in the future. This triangulation (past-present-future) in policymaking helps to emphasize the creativity of action, in addition to focusing on the value of experimentation in public policy.

In this process, CONEAT's experience was decisive as an explanatory factor that enabled SUMP and the contribution of the Faculty of Agronomy. As an academic underlined, 'The studies on soil erosion, started in the 60s [...] we obtained a database in three soils and geographical places with different topographies that allowed to validate the USLE/RUSLE model. Likewise, a software based on the model to be applied throughout the country was developed to teach in Faculty (its current version is Erosion 6.0) [...] Subsequently, further research on soil erosion measurement with interinstitutional agreements was continued'.

The implementation of SUMP allowed the capitalization of decades of research in the country. Thus, the process of policy design implied generative experimentation that sought to create a solution based on accumulated experience and knowledge. At the same time, in contrast to previous public efforts to deal with erosion, such as the CIDE-experience, the SUMP was less technocratic and top-down, while opening up for broad participation and knowledge claims from different traditions. Generative experiments in public policy are rooted in the experience and the situation of those doing the experiment

(experiential and problem-oriented). There is no a priori or sense of the certainty regarding the solution to an issue, but it is rather learnt and refined as it is implemented (iteration), and simultaneously, the capacity of the experiment implementation is constructed (transformation) (Ansell and Bartenberger 2016).

Conclusion

The great transformation of the agricultural-livestock sector with the expansion of soybeans has increased the level of uncertainty and complexity in decision-making and relocated the debate of the public policies regarding the relevance of environmental issues, and specifically soil erosion. In many ways, the market operations were faster than the labyrinthine governmental approach. Though soil degradation processes intensified after a few years of continuous cropping (around 2006/07), SUMP did not become obligatory until 2013. Governance systems need to be more flexible as new ways of managing public affairs based on the idea of deliberation, experimentation, exchange and co-responsibility are needed, leaving aside the traditional principles of hierarchy and specialization.

The Uruguayan government put on the public agenda the importance of soil rotation with the Soil Use and Management Plans. While it took relatively long time for the SUMP to come into force (which was harmful for the soils), it is important to remember that it necessarily takes a lot of time to engage in a relatively innovative, experimental and participatory decision-making process. Generative experimentation focuses on the design process of the policy, reframing the problem and improving solutions through iteration. This was, as mentioned, one of the main elements behind the high acceptance among farmers for the public policy. SUMP as a potential case of generative experimentation, lead us to reflect on the possibilities for emergent models of experimentalist governance based on new capabilities.

During the pilot program the solution co-designed between policy makers, academia, producers, producers' associations, and external technicians to control soil erosion, was rehearsed and adjusted based on constant feedback from the context. This sort of experimentation that seeks the continuous refinement of ideas to make them successful responds to a 'generative' logic of experimentation that differs from those of controlled and Darwinian experimentation as it attempts to prevent failure based on abductive inferences (Ansell and Bartenberger 2016). As mentioned, the transdisciplinarity of the design was also a key factor. These elements of the policy design can potentially also be key variables for successful environmental governance elsewhere. However, it is important to remember that there are also country-specific factors involved in the Uruguayan case. This paper has shown the importance of the strong tradition of 'rational' scientific planning, accumulated site-specific knowledge of the soils and a legislative framework that allows the state to ensure sustainable practices of land also in private property, in line with a view on the lands as a public good.

Although promising and innovative as this policy can be considered, there is still plenty of room for improvement.

Main challenges include sustaining innovation in order to adapt this policy through time considering alternation of authorities and the ruling parties, the weight of agriculture in the economy and the high volatility of the market, changes in the economic circumstances, and the high climatic variability in which the agricultural system develops without any possibility of significant subsidies of any kind. Also, it is vital to create instruments to control the plans compliance and implementation of the sanctions envisaged. This requires new institutional designs, synergizing initiatives and infrastructures in the territory.

Even though the legislation and the implementation have been improved, outlined weaknesses by its critics can compromise its efficacy. The main criticisms to the law No. 18,564/09 include the outdated cartography to develop the land use plans at a small scale, and the reductionism to the soil loss rate as the only parameter considered to approve the land use plans. The government does not consider qualitative parameters to estimate soil quality; for instance, the C/N balance (fundamental to determine soil fertility) is not taken in consideration.

Preventing soil erosion alone does not solve the impact on ecosystem services such as the supply of drinking water and biodiversity, amongst others. These are critical challenges for the country in the forthcoming years. In practical terms, addressing these issues will require, for example, new fertilizers management and practices, dairy farm effluents and management of buffer zones.

Furthermore, SUMP should not be kept in isolation but instead look towards the integration with other key government policies in natural resource management such as the national water policy, agrochemicals satellite control and so forth. Likewise, the data supporting this policy should be embedded in a more extensive agricultural information system that informs decisions within the public and private sectors.

All these issues that should be addressed as soon as possible open a window of opportunity for more experimentation processes to deal with sustainability problems. Under an experimentation lens, public policies are seen as learning processes that need to be monitored, evaluated, and adapted over time. Thus, the process of public policy design is not divided into stages; it is designed and then implemented, although it is continually updated and adjusted. In generative experimentation, the policy is open to amendments and changes as it evolves. With that aim, it is essential to maintain monitoring and evaluation processes incorporating external actors (producers, technicians, academia). Each management action is an opportunity to learn more about how to adapt and transform to the circumstances by changing and combining the characteristics of dynamic learning and collaborative management.

Notes

¹ CIDE was an interministerial public body in Uruguay that operated between 1960 and 1967.

² A key figure here was Dr. Carlos Fynn, who begun the work of soil classification within the department of livestock and agriculture, and initiated courses in soil

management and conservation at FAGRO (Petraglia et al. 1982).

Competing Interests

The authors have no competing interests to declare.

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