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Prospects for regenerative agriculture in Chile

Posibilidades para la agricultura regenerativa en Chile

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A global perspective, why we need a greener agriculture?

"I am a photosynthesis manager and an ecosystem-service provider". This profound statement was made by a Swedish farmer some years ago (Wratten, 2018). Few farmers describe their occupation in this way. However, there is a major body of work giving substantial evidence that current high-input farming (Figure 1) has no future without changes to its approach (Pretty *et al*., 2018). One reason for this view is that agriculture is one of the main causes of climate disturbance, largely driven by changes in land-use practices (Bennetzen *et al*., 2016). The main consequence has been biodiversity loss (Sala *et al*., 2000). A very worrying example of this is that human activities have made 60% of mammal, bird, fish and reptile species extinct since 1970, as consumption of food and resources by the global human population has de-stabilised the 'web of life' (Carrington and Watts, 2018). In more scientific language, we are losing ecosystem functions provided by nature at an alarming rate and with that, ecosystem (nature's) services are declining rapidly. Examples are declines in pollination, predation of pests and soil services. The seriousness of these losses was recently reported by workers at the University of Sheffield, UK, who predicted that Britain has only 100 harvests remaining before that country's soils are no longer suitable for growing crops (Dunnett, 2014).

Compounding the above threats to future farming was the evidence found by Vitousek *et al*. (1997), who showed that half the nitrogen circulating in the earth's fresh and salt water, soil and atmosphere is anthropogenic. This means that it is based on the use of fossil fuels and put there indirectly by mankind. In fact, we are now considered to be living in the Anthropocene in which man's activities are affecting the earth at a global scale (Zalasiewicz *et al*., 2010). World population has risen 2.5-fold since 1960 and yet per-capita food production has grown by only 50% over the same period (Tilman, 1999). Achieving that growth in food produc-

Figure 1. The 'perfect monoculture'. Here, lettuce is used as an example. Canterbury, New Zealand. Photo: Alistair Pullin.
Figura 1. El ´monocultivo perfecto´. Aquí, lechuga se utiliza como un ejemplo. Canterbury, Nueva Zelanda. Foto: Alistair Pullin.

tion through orthodox agricultural practices has been the largest cause of greenhouse-gas emissions, gross consumptive over-use of fresh water, loading of nutrients into the biosphere (nitrogen and phosphorus) and a major cause of pollution due to pesticides (Campbell *et al*., 2017).

Predictions for future production and its negative consequences are dire, so a new approach is sorely needed. In fact, De Schutter (2010), reported to the United Nations that if agroecology was adopted by major food-producing nations, global food yields would double in one decade. “Business as usual” cannot possibly achieve that. Recognising this, there is a high and increasing level of interest in ‘sustainable intensification’ (Bommarco *et al*., 2013), which can be perceived as a transitional step towards an agroecological system because it uses ecological principles to promote agroecosystem sustainability (Struik and Kuyper, 2017). This apparently oxymoronic statement has to a large extent been supplanted by the term ‘regenerative agriculture’, which is partly based on restoring ecological functions by promoting functional biodiversity in degraded agricultural landscapes (LaCanne and Lundgren, 2018). Thus, the principles behind regenerative agriculture include abandoning tillage, eliminating spatio-temporal consequences of bare soil, enhancing plant diversity on the farm and integrating livestock and crops in farm operations (LaCanne and Lundgren, 2018). In this sense, regenerative agriculture could be considered as a connected series of agricultural practices that can be applied in agroecological farming systems (Figure 2). The latter framework goes beyond enhancing only production and efficiency in farms by seeking a paradigm shift in the conception and development of the whole food web involved in conventional agricultural systems, from an economic, social and ecological perspective (Dumont *et al*., 2018; Gliessman, 2018). Thus, agroecology has been defined as the “ecology of food systems” (Francis *et al*., 2003).

Pretty *et al*. (2018), recently estimated that 163 million farms (29% of all worldwide) have crossed a redesign threshold, practising sustainable intensification on 453 million hectares of agricultural land (9% of worldwide total). The implications of this are pro-

Figure 2. A diversified agroecological farm. Santa Cruz, California. Photo: Mauricio González-Chang.

Figura 2. Una granja agroecológica diversificada. Santa Cruz, California. Foto: Mauricio González-Chang.

found but the key challenge is the development of implementation pathways to help farmers effect changes of this type. It would not be an exaggeration to say that most insecticides, fungicides, herbicides and fertilisers are wasted worldwide, with obvious economic, social and environmental implications. Recent evidence of this comes from the work of LaCanne and Lundgren (2018), who showed that corn (maize) treated with insecticides had approximately 130 pest individuals m^{-2}, while that crop in which some form of regenerative agriculture had been practised (but no insecticides used) had fewer than 20 pests m^{-2}. The importance of this dramatic and surprising result is reinforced by another recent publication by Fausti *et al*. (2018), which showed that insecticide use on genetically modified corn in South Dakota, USA, has increased since 1969 even though the GM corn used was intended to reduce numbers of some pests. This increase in insecticide use was derived largely from an increasing reliance on monocultural corn rather than mixed-cropping agriculture. Such increases can lead to insecticide resistance so that some insect species can assume pest status which would not be the case if pesticides were not used. A key example is the brown plant hopper (*Niliparvata lugens* Stål) on rice which did not have pest status until prophylactic pesticide use became the norm (K.L. Heong in Gurr *et al*., 2016).

Now, broad-spectrum pesticides are being sold as ‘fast-moving consumer goods’ in many Asian rural outlets, together with food and other items. In some parts of Asia, the level of farmers’ education is so low that they are unable to decide on the merits or otherwise of these products (Wyckhuys *et al*., 2018), which are promoted widely by pesticide companies (Reganold and Wachter, 2016). Because of this approach, K.L. Heong (personal communication) considers that integrated pest management (IPM) is “dead” in many countries. One reason for this is that the first step in any IPM approach is crop scouting in which pest numbers are assessed regularly, ideally in relation to economic injury levels (EILs). Many governments worldwide no longer support this activity so EILs do not exist and prophylaxis often takes their place as a consequence.

The above information presents a serious challenge to feeding the human population now and in the future. Developed countries frequently express their wish to help feed those impoverished populations but apart from famine situations, exporting food in bulk is not an appropriate solution. An alternative approach is exporting agricultural knowledge to these countries but if this implies sending established ‘western’ methods to the developing world, this will compound existing problems. Using farmer field schools (Amudavi *et al*., 2009), farmer to farmer strategies (Holt-Giménez, 2008), agroecological lighthouses (Nicholls and Altieri, 2018), and other ways of communicating and implementing change through agroecology is the only approach with good prospects for mitigating hunger in the long term (Warner, 2006; De Schutter, 2010). The aim of this viewpoint is to discuss potential barriers for a widespread adoption of agroecological principles that can enhance functional biodiversity in large-scale farming systems in Chile, through regenerative agriculture.

Can regenerative agriculture be widely adopted in Chile?

Agriculture in Chile is the second-most relevant primary economic activity after mining, contributing to 7.3% to GDP, in which the production of fruits, vegetables, wheat, milk, meat and wine are the most important (ODEPA, 2017). As in many parts of the world, a high proportion of the Chilean agricultural area is dominated by monocultures that have a profound impact on the environment and human health. For example, in Petorca, Valparaiso region, the monocultural production of avocado has been using water from rivers at unprecedented rates, with consequences from not only a hydrological and ecological perspective, but also from a social and ethical one where the quantity of available water for human consumption has been reduced (https://www.theguardian.com/environment/2018/may/17/chilean-villagers-claim-british-appetite-for-avocados-is-draining-region-dry). This could be termed ‘consumptive agriculture’. In the latter example, regenerative agriculture could increase water availability in soils by enhancing functional biodiversity, as demonstrated in different parts of the world where biodiversity has been promoted (Lin, 2010; Wratten *et al*., 2012; Altieri *et al*., 2015). Furthermore, from Valparaiso to the Maule region, some farms that grow vegetables as monocultures spray synthetic agro-chemicals up to 12 times $season^{-1}$ (González-Chang, personal observation). This un-regulated use of agro-chemicals severely damages human health, as recently highlighted by scientists that found cognitive alterations of agriculture and non-agriculture workers related to organophosphate applications in the Maule region (Muñoz-Quezada *et al*., 2017; Pizarro *et al*., 2018). Regenerative agriculture can reduce the need for pesticide use in pest control (LaCanne and Lundgren, 2018) by the addition of non-crop vegetation, such as flowering plants that provide shelter, nectar, alternative food sources for natural enemies and pollen (SNAP) (Gurr *et al*., 2017; González-Chang, *et al*., 2019), as recently demonstrated in Asian rice fields (Gurr *et al*., 2016). Moreover, industrialised livestock production of pigs and poultry in the central area of Chile (mainly in the O’Higgins region) is currently in question by environmental organizations, municipalities and the public, especially when considering aspects of human wellbeing related to unpleasant odours and water scarcity produced by such an industrialised activity (http://www.magisterenperiodismo.com/reportajes2018/tag/empresas-que-contaminan/). Through enhancing functional biodiversity to pastures, regenerative agriculture can increase pasture resistance to climatic changes, such as drought (Tilman *et al*., 2006; Altieri *et al*., 2015) and provide multiple ecosystem services, which in turn can enhance animal and human wellbeing (Dumont *et al*., 2018). In New Zealand, establishing plants of *Miscanthus* x *giganteus* Greef et Deu, at the edge of pasture fields improved several ecosystem services, such as pollination, water conservation, biomass production, nitrogen supply, soil quality and conservation of endemic lizards (Littlejohn *et al*., 2019). That Miscanthus work, as well as successful examples presented in recent research (Gurr *et al*., 2016, 2017; LaCanne and Lundgren, 2018; Nicholls and Altieri, 2018; González-Chang *et al*., 2019; Shields *et al*., 2019), could inspire Chilean agronomists, farmers, scientists and policy makers to promote biodiversity-based agricultural systems. However, such implementation is not just a matter of "copy and paste" of techniques but requires an understanding of the ecological dynamics and potential ecosystem dis-services that any agricultural management could have. Therefore, the lack of widespread adoption of biodiversity-based farming techniques in Chile and elsewhere is probably related to a lack of ecological protocols that farmers can easily apply. Thus, one of the impediments that affects the creation of these protocols is that locally tested scientific knowledge that farmers can easily apply is usually unavailable (González-Chang *et al*., 2019; Shields *et al*., 2019). Once research is able to produce applied ecological protocols for conventionally managed farms, and when adequate channels that spread that knowledge amongst farmers exist, such as farmer field schools, farmer to farmer strategies and agroecological lighthouses, regenerative agriculture can truly help in producing a change in conventional Chilean agricultural systems, from monoculture to diversified agroecosystems. A remarkable example of agroecological lighthouses (i.e., an agroecological demonstrative farm) in Chile is the experience carried out by CET (Centro de Educación y Tecnología), a non-governmental organisation (NGO) that since the 1980s has been promoting agroecological practices amongst small farmers enhancing they self-sufficiency and food sovereignty (Nicholls and Altieri, 2018). In the last 20 years, more than 130,000 people had visited CET in the Biobío region, 85% of which have been small farmers, highlighting the key role of this agroecological lighthouse in spreading agroecological knowledge in Chile (Nicholls and Altieri, 2018). Several initiatives to promote agroecology in Chile have been carried out since CET started, from NGOs and social movements, to universities and the government in recent years (Montalba *et al*., 2016). However, despite the enormous advance of agroecology in Chile that has mainly benefited small farmers, there is still a lack of adoption of such techniques amongst large-scale farmers. Despite that a small number of vineyard and berry companies have adopted agroecological principles on their farms (Montalba *et al*., 2016), a lack of a widespread adoption amongst large-scale farmers is possibly by political reasons, pressures from agro-chemical companies, and driven by a historical interest for studying monocultural systems by Chilean universities, as has been seen elsewhere as well (Reganold and Wachter, 2016). Because agroecology has an ideological and political component amongst its roots (Wezel *et al*., 2009), it may deter some farmers with different political inclinations in its adoption. Thus, regenerative agriculture can be considered as a network of practices based on enhancing farm biodiversity and ecosystem functions, and then, it can help at reducing the environmental and human health problems that Chilean workers and farmers face without making a profound change in large-scale farmers' political ideals. This could be the first step to change Chile's current industrialised agricultural paradigm.

Finally, basic scientific research is not the only way, when it is applied, in which agriculture in Chile can changed, especially considering that Chilean funds to perform scientific research are only 0.36 % of GDP, the lowest investment in science amongst OCDE countries (http://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm). Under this scenario, producing enough agro-ecological protocols for all the different growing regions in Chile is a challenge that must also be faced by the government, policy makers and stakeholders. Therefore, a paradigm shift from conventional to regenerative agriculture and then to agroecology needs to articulate different parts of society, so these changes are not only produced by particular ecological protocols but also by a change in how food production, from the soil to the consumer, is perceived and valued amongst the public (Francis *et al*., 2003; Gliessman, 2018). Thus, such a paradigm shift can be jointly led by Chilean universities, farmers, consumers and the government, effectively promoting substantial changes in Chilean agricultural systems, a change which is sorely needed for Chilean agriculture to meet the major challenges facing global agriculture in the coming decades.

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