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Sustainability transition pathways through ecological intensification: an assessment of vegetable food systems in Chile

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ABSTRACT

Ecological intensification has been proposed as a promising lever for a transition towards more sustainable food systems. Various food systems exist that are based on ecological intensification and may have potential for a sustainability transition. Little is known, however, about their diversity and about how they perform against dominant systems in terms of the multiple societal goals. The aim of this study is to contribute to knowledge about sustainability transitions in food systems through an empirical analysis of vegetable food systems in Chile. The study (i) characterizes the diversity of vegetable food systems in Chile (ii) evaluates the food systems in terms of multiple societal goals, and (iii) assesses their potential for supporting sustainability transition pathways from the perspective of ecological intensification. Results indicate that among the five vegetable food system types, the agroecological and the small organic have potential to foster a sustainability transition. Nevertheless, these systems are small and localized, and scaling them requires actions to remove barriers in the relations with the agri-food regime and among themselves. The broader relevance of this analysis is that there needs to be awareness in research on transitions about the diversity of food systems present in countries and how they interact.

KEYWORDS

Food system; ecological intensification; sustainability transition; conventional food system; alternative food system

1. Introduction

There is urgent need for a transition to food systems that consider objectives beyond food supply and economic performance, to encompass broader societal goals such as environmental protection, social welfare, and food and nutrition security (e.g. Béné et al., 2019; Caron et al., 2018; De Schutter, 2017; IPES-Food, 2016). Ecological intensification (EI) has been proposed as a promising lever for a transition to more sustainable food systems (Bommarco, Kleijn, & Potts, 2013; Doré et al., 2011; Tittonell et al., 2016). It involves making smart use of the natural functionalities of the ecosystem to support the production of food and ecosystem services in a sustainable way (Bommarco et al., 2013; Tittonell, 2014). EI principally applies to the production systems level. Moving from farm to the landscape and the food system level will require the re-design of agroecosystems (Tittonell, 2014), the articulation with supportive value chains (Duru, Therond, & Fares, 2015), adequate structural conditions (e.g. extension services, innovation policies, and research and development programmes),

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dedicated agents that favour and promote more diversified agricultural production, and inclusive approaches to food production, provisioning and consumption of diversified food (Bui, Cardona, Lamine, & Cerf, 2016; Klerkx, Aarts, & Leeuwis, 2010; Seyfang, 2006).

Various food systems that are in line with EI (e.g. based on agroecological production systems and some forms of organic farming, supported by alternative food networks such as marketing cooperatives, public food procurement programmes and farmer's markets), have been advanced harbouring promising characteristics for improving current unsustainable dominant food systems (Darnhofer, 2014; Doré et al., 2011; Duru et al., 2015; Tittonell et al., 2016). Despite their potential and actual efforts to create opportunities for a transition process, these systems typically have few links to or effect on the dominant food systems. Their lack of visibility often leads to limited knowledge at the policy level about alternative food system development options in terms of their diversity, forms of organization and underlying values (Gaitán-Cremaschi et al., 2019; Plumecocq et al., 2018). In addition, there is limited information about how these alternative systems perform in terms of the multiple, and sometimes conflicting societal goals of economic performance, environmental protection, social welfare, and food and nutrition security (IPES-Food, 2016). More insight into alternatives is essential for discussing and negotiating the possible pathways of transition to future food systems (Plumecocq et al., 2018).

We address this gap in knowledge by presenting an empirical analysis of diversity in vegetable food systems in Chile from the perspective of a transition based on EI. To do so, we apply the conceptual and methodological framework developed by Gaitán-Cremaschi et al. (2019), which aims to provide an actionable basis to food system analysis. Specifically, we aim to (i) unravel diversity of the co-existing vegetable food systems, their structural characteristics and underlying values in production and consumption; (ii) provide insights on how these food systems enact different interpretations of sustainability and food and nutrition security; and (iii) provide empirical insights on the current levels of food system change based on EI. Beyond the case of vegetables, the paper aims to demonstrate the value of the approach for providing insight into the diversity of food systems in view of a desired alternative paradigm (in this case EI).

This paper is structured as follows. In Sections 2 and 3, we present the methodology and data, respectively, used to identify and characterize the diversity of co-existing Chilean vegetable food systems following a gradient of EI. In Section 4, we present the results of the food system typology, and assess food system types in terms of economic performance, environmental protection, social welfare, and food and nutrition security. We then classify the systems as dominant food systems, alternative systems or hybrid forms. In Section 5, we discuss the potential of the system types to support a sustainability transition based on EI.

2. Methodological framework

Gaitán-Cremaschi et al. (2019) proposed a seven-step methodological framework, which we outline below to: (i) construct a typology of food systems; (ii) evaluate food system performance; and (iii) classify the systems as dominant food systems, alternative systems or hybrid forms. For a detailed description of the framework see Gaitán-Cremaschi et al. (2019). We applied these seven steps to vegetable food systems in Chile from the perspective of EI. We then identified current levels of food system change drawing on a framework put forward by Tittonell (2014) and Gliessman (2015), and assessed the potential of the different food system types to contribute to sustainability transitions from the perspective of EI.

2.1. Step 1. Identifying the food system and defining the system boundaries

Vegetable food systems are only one component of the whole food system, in which grains, dairy products, livestock, fish, fruits, among others, play an important role in food and nutrition security. However, vegetable food systems were selected as they are increasingly recognized as essential to deal with the double-burden faced by countries like Chile: on the one hand, obesity and obesity-related diseases caused by changes in the diet, in which vegetables have become under-represented. Half of the population in Chile falls short in consuming the daily amount of vegetables recommended by the WHO (Albala, Vio, Kain, & Uauy, 2002; Chile National Health Survey, 2017). On the other hand, the negative impacts of agricultural production on the environment, society and human health, especially resulting of intensive use of chemical pesticides (Altieri &

Table 1. Variables that were used for identifying vegetable production systems in Chile along a gradient of ecological intensification (EI).

Characteristic	Variable	Unit
a. Size	a. Total area of farm	Hectares
b. Labour	b1. Family labour	% over total labour
	b2. Hired labour	% over total labour
c. EI practices/agronomic management (Level of EI)	c1. Use of fertilizers and pesticides/dependence on external inputs	Yes/no
	c2. Use of manure and compost	Yes/no
	c3. Use of bio-control agents	Yes/no
	c4. Crop rotation	Yes/no
	c5. Organic production	Yes/no
	c6. Crop diversification	Yes/no
d. Tax compliance	d. Tax formality	Low, medium, high
e. Management level	e. Management level	Low, medium, high
f. Production orientation	f1. Market	Proportion
	f2. Auto-consumption	Proportion

Toledo, 2011; INE, 2016; Rap-Chile, 2018). The diversification component of vegetable production offer opportunities for reducing pesticide use implementing strategies based on EI (Joosten, Dijkxhoorn, Sertse, & Ruben, 2015; Schreinemachers, Simmons, & Wopereis, 2018).

The Chilean vegetable sector is affected by imports of inputs such as crop varieties, fertilizers and pesticides produced by multinational companies. Nevertheless, vegetables are produced mainly for the domestic market justifying the choice of the national geographic system boundaries.

2.2. Step 2. Identifying agricultural production system types

This step consisted of setting up agricultural production system typologies. To do so, an expert-based typology of vegetable production systems was constructed based on a selection of variables that describe resources and asset levels and a gradient of EI (Alvarez, Paas, Descheemaeker, Tittonell, & Groot, 2014; Gaitán-Cremaschi et al., 2019). Table 1 presents the variables that were used to characterize the diversity of vegetable production systems.

2.3. Step 3. Identifying value chain types

This step consisted of identifying and describing the value chains that link each agricultural production system type in Step 2 with consumers. A value chain may have multiple marketing channels. Following Trienekens (2011) and Trienekens, Velzen, Lees, Saunders, and Pascucci (2018), the value chains were identified using variables that describe their network structure (i.e. vertical and horizontal relationships between value chain actors) and their governance form. Governance forms included the bilateral contracts and their coordination mechanisms on price, volume, safety (with a focus on pesticides) and quality; the network ('whole chain') governance and; the informal coordination mechanisms such as trust. Table 2 presents the variables and the qualitative indicators used to identify and describe the value chain types.

2.4. Step 4. Identifying the multiple set-ups of support structures for functioning and system performance

This step consisted of identifying the structures that support innovation and everyday functioning of vegetable production systems and their associated value chains. The support structures included research and development (R&D) programmes, extension services and innovation policy. In Chile, many of the environmental and health impacts of vegetable food systems are caused by the indiscriminate use of chemical pesticides. Therefore, the focus is on those structures that have an influence on the use and control of pesticides in agricultural production systems and that favour or constrain commercialization of vegetables with low-or-no pesticides.

2.5. Step 5. Identifying the diversity of food systems

In this step a food system typology was constructed by synthetizing the results of Steps 2–4. A vegetable food system type was constituted by a vegetable production system type (Step 2), connected to consumers by a value chain type (Step 3), both encompassed by a set-up of structures that support their innovation and everyday functioning (Step 4).

Table 2. Variables that were used for the identification and description of value chains in Chile linking vegetable production system types to markets and consumers.

Characteristics of the value chain	Variable	Unit
a. Network (value chain) structure	a1. Vertical relationships	Collaboration between actors involved in different activities of the value chain
	a2. Horizontal relationships	Collaboration between actors involved in the same activity of the value chain
b. Value chain governance	b1. Bilateral contracts	
	b11. Type of agreements	Spot-market, verbal agreement, formal written contract, vertical integration
	b12. Price agreements	Actor setting the price/duration of price agreements
	b13. Volume agreements	Specifications of agreement (e.g. fixed/variable/spot volume) Duration of volume agreements
	b14. Safety	Actor setting and controlling safety requirements / Scope of the safety requirements (one actor – whole chain)
	b15. Quality	Intrinsic quality attributes (e.g. size, color, post-harvest life) Extrinsic quality requirements (e.g. place, sustainability)
c. Network governance	c1. Leadership	Main actor taking decisions in the value chain
	c2. Shared governance	Frequency of meetings between members of the chain and participation in decision-making
d. Informal mechanisms of relations in the value chain	d. Trust	Low, medium, high

2.6. Step 6. Assessing food system performance

This step consisted of assessing the performance of the food system types identified in Step 5. To do so, we built a list of 18 statements encompassing the four food system goals, i.e. economic performance environmental protection, social welfare, and food and nutrition security (Appendix 1). The statements were based on the scientific literature on the principles of a sustainable food system (EAT initiative, 2015; FAO, 2014a; FAO, 2014b; Gustafson et al., 2016; IPES-Food, 2015; Nugent et al., 2015; Peano, Tecco, Dansero, Girgenti, & Sottile, 2015). Experts were asked to assess the perceived current performance of each vegetable food system type in terms of each of the listed statements.

2.7. Step 7. Classifying food systems as dominant, alternative or hybrid

This step consisted of classifying the vegetable food systems identified in Step 5 as dominant, alternative and hybrid systems. The dominant food systems refer to those systems operating in line with the Chilean agri-food regime, which describes the prevailing set of technical and social elements that guide food production, processing, distribution and consumption (e.g. rules and policy measures, standards, farming practices and the associated inputs, vision on the conception of sustainability) (Ingram, 2015; Smith, Voß, & Grin, 2010). The alternative food systems are those whose practices deviate radically from those that are found in the dominant systems and therefore seek to overcome 'business as usual'. The hybrid systems are those that are configured at the intersection between the alternative and dominant systems. To classify the systems, we used the indicator 'market share in production volume' (Gaitán-Cremaschi et al., 2019). Vegetable food systems with the largest production volumes were classified as being aligned and supported by the Chilean agri-food regime. We then classified the other systems as alternative vegetable food systems or hybrid forms.

3. Data

Data for Steps 2–4 of the methodological framework (see subsection 2.2, 2.3 and 2.4) were collected from June 2017 to August 2017 through 33 face–to–face semi-structured interviews with food system actors and experts with knowledge on the vegetable sector in Chile, either with a regional or national outlook. Interviews were recorded, transcribed, coded and analysed with reference to the construction of vegetable production system types, value chain types and set-ups of support structures. Data collected through the interviews were triangulated with information from published reports, documents and field observations, and synthetized into vegetable food system types (Step 5 of the framework, subsection 2.5). After characterizing the types, the results were validated in

November 2018 through 20 face–to–face semi-structured interviews (4 actors were the same as the interviewees in Steps 2–4). Data to evaluate food system performance (Step 6 of the framework, subsection 2.6) were collected through 31 questionnaires completed either by the actors and experts that participated in the first round of interviews ($n = 7$) or in the validation of results ($n = 20$). The remaining four actors included two agricultural producers and two publicly funded technical advisors. We asked the actors and experts to score current performance of each food system type for 18 statements using a five-point Likert scale, where 0 represented a strongly negative performance of the system type in relation to a given statement, and 5 a strongly positive performance. The higher the score, the better the system performance. In total 53 persons participated in the interviews, validation and/or questionnaire. Appendix 2 provides an overview of the food system actors and experts that were approached for the interviews, validation or questionnaire. Data to classify vegetable food system types as dominant, alternative or hybrid (Step 7 of the framework, subsection 2.7.) were collected from published reports.

4. Results

4.1. Co-existing vegetable food system types

Synthetizing the results of Step 2 to Step 4, we arrived at a typology of five vegetable food system types (Step 5): *Type I*: Small, conventional/traditional system; *Type II*: Small, agroecological system; *Type III*: Small, organic system; *Type IV*: Large, organic system and; *Type V*: Large, conventional system. The five vegetable food systems types are depicted in Figure 1. The main characteristics of the systems in terms of their three components, i.e. agricultural production (Step 2), value chain (Step 3) and support structures (Step 4), are described and compared in next sections. A detailed description of each vegetable food system type can be found in Appendix 3.

4.2. Vegetable production system types along a gradient of ecological intensification (EI)

The main characteristics of the agricultural production systems associated to each of the five vegetable food system types are summarized in Table 3.

Type I 'small, conventional/traditional system' and type II 'small, agroecological system', are characterized by small-sized farms (less than 12 hectares) that rely on high use of family labour. Farms in these types commonly have very low to high tax formality, very low to medium level of organization of marketing activities and limited access to market information (Schwartz, Kern, & Hernández, 2013). Farmers in system Type I are commonly not part of farmer's associations whereas farmers in system Type II are in some cases part of agroecological communities.

In terms of agronomic management, Type I farms have a conventional approach to farming that typically involves the use of synthetic fertilizers, synthetic pesticides, and mono-cropping. In some cases, especially in southern regions of Chile such as Bio Bio, La Araucanía, and Los Ríos, conventional farming is combined with traditional and indigenous farm management practices (e.g. zero tillage, intercropping and use of local resources), which enable reductions in pesticide use and the replacement of mono-cropping by more diversified systems. Pesticide use in Type I farms varies from low to high and depends on factors such as economic resources, technical advice, training, labour availability, scale of operations, farm structure and climate. However, as one of the interviewees stated: *'In many cases, a farmer that belongs to this type [Type I] does not apply a large amount of chemical pesticides. They do not have money for that'*. As result of their agronomic management, farms in this system exhibit low to medium levels of EI. Pesticide management and disposal is controlled by the Agricultural and Livestock Service (SAG). This control is limited as there are many and geographically highly dispersed farms. Monitoring of the quantity of pesticides that are applied and of pesticide residues on sold vegetables is almost non-existent.

Farms in the small, agroecological system (Type II) apply what is locally referred to as 'agroecological management'.[1] This management includes practices such as conservation of seeds, application of bio-inputs (e.g. worm compost), crop diversification, crop rotations, crop spatial diversity and intercropping, manual weeding and mulching (Martínez-Torres, Namdar-Iraní, & Saa-Isamit, 2017). In some farms, there is also varying use of synthetic pesticides and fertilizers. Depending on the adoption of agroecological practices and on the use of external inputs, farms within this system type can be catalogued as fully agroecological or in transition. As result of the agronomic management, these farms exhibit medium to very high levels of EI. It is worth noting that many of these farmers do not intend to be agroecological per

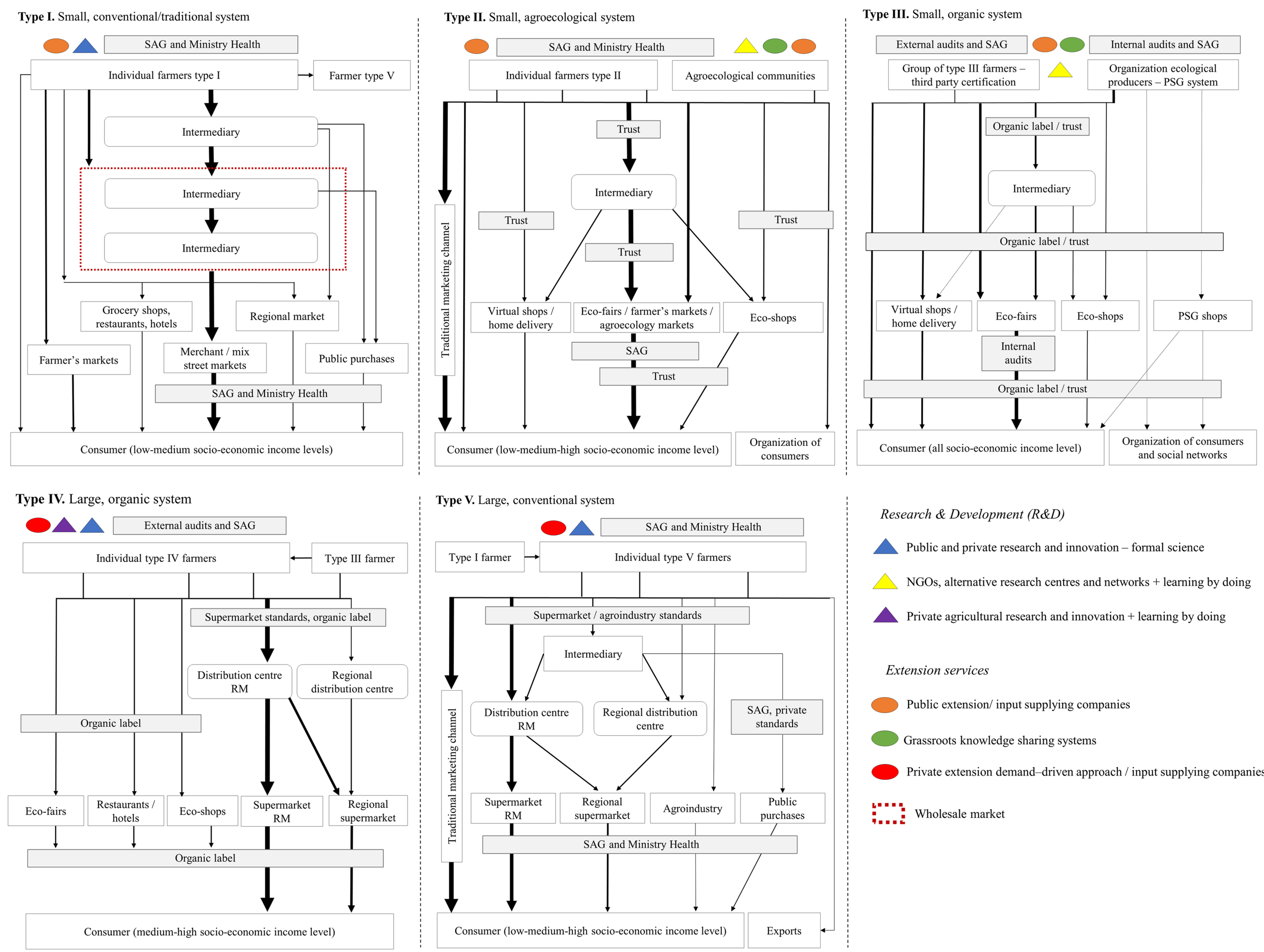

Figure 1. Vegetable food system types in Chile. The arrows indicate the flow of product. The thicker the arrow, the larger the quantity of vegetables that are sold through the marketing channel. The grey squares refer to pesticide control mechanisms undertaken by: (i) public entities (i.e. SAG and Ministry of Health); (ii) organic certification mechanisms, i.e. third party or Participatory Guarantee System (PGS); (iii) standards set by food system actors; or (iv) relying on relations of trust. R&D and extension services focus at the agricultural production level. However, in some cases they address components beyond agricultural production and work on issues of human capital development and market access facilitation. *RM*: Metropolitan region.

Table 3. Summary of the main characteristics of vegetable production system types in Chile along a gradient of Ecological Intensification (EI).

Characteristics	Type I	Type II	Type III	Type IV	Type V
a. Area	<12 ha HRB	<12 ha HRB	<15 ha	>15 ha	>12 ha HRB
b1. Family labour	+++	+++	++	-	+/−
b2. Hired labour	+/−	+/−	+	+++	+++
c. Level of EI	+/− to +	+ to +++	+ to +++	+/− to +	− to +/−
d. Tax compliance	− to ++	− to ++	++ to +++	+++	+ to +++
e. Management level	− to +	− to +	+/− to ++	++ to +++	+ to +++
f1. Market	++	++	++	+++	+++
f2. Auto-consumption	++	++	+	−	− to +/−

Type I: Small, conventional/traditional system; *Type II*: Small, agroecological system; *Type III*: Small, organic system; *Type IV*: Large, organic system; *Type V*: Large, conventional system.
+++ means very strong/very high, ++ means strong/high, + means moderate/medium, +/− means limited/low, − means lack of/very low.

se. They are agroecological as result of their scale of production, the productive structure of their farms and because of their culture and their traditional ecological knowledge. For example, as one of the interviewees stated: '*Especially in southern regions of Chile where, for example, the Mapuche tradition exists, farmers practice agroecology not for the concept of producing a differentiated product for the market, but simply because they produce in that way*'. The SAG monitors pesticide management and disposal but, in line with Type I farms, controls are limited.

Type III 'small, organic system', Type IV 'large, organic system' and; Type V 'large, conventional system' are characterized by larger farms, higher tax formality and higher management level in comparison to farms of Type I and Type II. The workforce in these farms comes primarily from hiring temporary and permanent labour. Farms in system Type III also use high levels of family labour. Type III farms belong to small-medium holders and to the so-called 'neo-rurals' (Ratier, 2002), who are mostly advanced-age and academically formed producers that have lived in the regional capitals of Chile or in foreign countries. Farms in system Type IV and Type V are in many cases part of consolidated companies with a clear economic focus, which reflects in high levels of organization for marketing activities and access to market information.

In terms of the agronomic management, farms in the small, organic system (Type III) apply organic farming. This implies complying with the Chilean Law No. 20089 of 2006 (SAG-MINAGRI) for organic production, which is regulated and legally enforced by the SAG. Although the agronomic management in these farms resembles in many cases the agronomic management of Type II farms and follows agroecological principles, Type III farms may utilize external organic inputs (e.g. bio-fertilizer Supermagro) and cannot make use of conventional synthetic fertilizers and pesticides. As result of the agronomic management, Type III farms result in medium to very high levels of EI. Certification in organic production is mostly achieved through the Participatory Guarantee System (PGS). To a lesser extent, small groups of farmers achieve certification by contracting the services of a third-party certification body. To obtain organic certification through the PGS, farmers organize themselves in associations of ecological producers, grassroots organizations that create locally-specific, non-hierarchical internal control systems to comply with the legal standards established in the law (Ríos-Núñez & Núñez-Yáñez, 2016).

Farms in the large, organic system (Type IV) apply organic farming through an input-substitution model that follows the same principles that are adhered to in conventional farming, i.e. curative measures that rely on external inputs of organic fertilizers and pesticides without challenging production in monocultures. To a lesser extent, farm management practices may also include the use of compost and crop rotations. Overall, farms in this system type exhibit low to medium levels of EI. Certification in organic production is achieved through a third-party certification body.

Agronomic management of farms in the large, conventional system (Type V) is conventional and includes, among others, use of external synthetic pesticides to control pests and diseases, commercial fertilizers, mono-cropping and intensive tillage. Pesticide intensity of farms in this Type varies from low to high. Pesticide management and disposal is monitored by the SAG more intensively than for Type II and Type III farms.

4.3. Value chain types

The main characteristics of the value chains associated to each of the five vegetable food system Types are summarized in Table 4.

Table 4. Summary of the main characteristics of value chains connecting the vegetable production system types in Chile to consumers.

Characteristics	Type I	Type II	Type III	Type IV	Type V
a1. Vertical relationships	+/−	+/− to ++	+ to ++	++ to +++	+/− to +++
a2. Horizontal relationships	+/−	+/− to ++	+ to ++	−	− to +/−
b11–b13 Strictness contr. price/ volume	+/−	+/− to +	+/− to ++	+ to +++	+ to +++
b14. Strictness contr. safety	−	+/− to +	+++	+++	− to ++
b15. Quality	size, colour, firmness and postharvest shelf-life	local production, health, food security and sustainability	organic label, local production, health, food security and sustainability	organic label, health, size, colour, texture, firmness, freshness, postharvest shelf-life	size, colour, firmness, texture, freshness, postharvest shelf-life
c1. Leadership	−	− to +	+ to ++	++	− to ++
c2. Shared governance	− to +	− to +	++	+/−	− to +/−
d. Trust	− to +	− to ++	++	+/− to +	+/− to +

Type I: Small, conventional/traditional system; *Type II*: Small, agroecological system; *Type III*: Small, organic system; *Type IV*: Large, organic system; *Type V*: Large, conventional system.
+++ means very strong/very high, ++ means strong/high, + means moderate/medium, +/− means limited/low, − means lack of/very low.

The value chain of the small, conventional/traditional system (Type I) is mainly constituted by the traditional marketing channel. This channel involves: farmers that sell their products to intermediaries at the farm or to intermediaries in wholesale markets; retailers such as those operating in merchant and mix street markets[2], grocery shops, restaurants, hotels and consumers. To a lesser extent, there are three other marketing channels involved in this value chain: direct selling by farmers in farmer's markets, direct selling between farmers and consumers and public purchases through distribution companies.

In the traditional marketing channel, there is limited horizontal and vertical collaboration. This channel relies mostly on spot market relations (between farmers and intermediaries and between wholesale intermediaries and retail intermediaries), although long-term informal relations may also exist. In spot market relations, the actors negotiate and conclude their transaction on price, volume and quality on the spot. Given their role in stocking vegetable products, intermediaries in wholesale markets are the main players in price setting (Boitano-Contreras, 2011). Spot market requirements on quality commonly relate to attributes such as size, colour, firmness and postharvest shelf-life. There are no traceability requirements regarding pesticide use and pesticide residues on food. In this marketing channel, power is highly asymmetrical. Intermediaries, especially those that buy vegetables at the farm and those in wholesale markets, have a better bargaining position than farmers and small retailers as they are better informed regarding prices and traded volumes, and have the logistics to store and transport the products (Schwartz et al., 2013). Power asymmetry, lack of transparency of market information and lack of knowledge about the way the different value chain actors operate, lead to relatively very low levels of trust along the chain (Sáez, Arriagada, Díaz, Tejero, & Contreras, 2015).

Consumers linked to system Type I mostly belong to low and medium socio-economic income categories, and to a lesser extent to high socio-economic income categories (FAO et al., 2013). The purchasing criteria of these consumers are primarily the price and the aesthetic quality of the product.

The products of the small, agroecological system (Type II) enter the value chain through a range of possible outlets. Farmers sell through the traditional marketing channel or through short marketing channels of food distribution, either voluntarily or forced as result of their small scale of operations. When entering the traditional channel, agroecological products cannot be sold as 'agroecological' because of the Chilean law on organic production. Therefore, agroecological farmers do not see agroecological production rewarded with a bonus price. Relationships in the traditional channel follow the same characteristics as those for Type I: limited horizontal and vertical collaboration, spot price, spot volume and spot quality requirements, limited traceability and limited control regarding pesticide use and content of pesticide residues in food, high power asymmetry, and low trust between the value chain actors.

The short marketing channels include farm gate sales, home delivery and virtual shops, specialized shops, farmer's markets, agroecological markets and eco-fairs. In these channels, Type II farmers deliver the products directly to consumers or via collective forms of organization such as agroecological groups and communities, and consumer groups.[3] Horizontal coordination in collective forms of organization usually entails sharing production information, preparing bio-inputs collectively, and arranging farmer's markets. Price and volume setting mechanisms in the short marketing channels are variable and may include spot price and spot volume, price agreed between farmers and buyers taking as reference the market price, or a pre-fixed price (especially in box-schemes). There are no control systems to ensure that practices in agricultural production systems follow the principles of agroecology and that products are free of pesticides. Control systems are mainly social and rely on relations of trust based on interpersonal relations and spatial proximity. For example, as one of the interviewees stated: *'For us, the guarantee of an agroecological product is trust'*.

Consumers linked to system Type II belong to any socio-economic income level group. Home delivery, virtual shops and specialized shops reach a more urban consumer. Main purchasing criteria of these consumers include attributes related to notions of place, health, and sustainability. On the contrary, farmer's and agroecological markets reach a more rural consumer. Main purchasing criteria of these consumers are related to notions of place and are based on proximity relations.

The value chain of the small, organic system (Type III) is constituted by the combination of multiple short marketing channels of food distribution that are often shared with Type II farmers (Ríos-Núñez & Núñez-Yáñez, 2016). In these channels, commercialization of vegetables is undertaken individually or may involve more complex institutional arrangements based on relations of trust and proximity. In the first case, short marketing channels include farm gate sales, home delivery (box-schemes) and virtual shops, or the direct delivery to specialized shops. The type of agreements between actors range from spot transactions to long-term relationships with informal agreements on price (with organic bonus), volume and quality. More complex institutional arrangements include eco-fairs and to lesser extent PGS shops, which represent the marketing unit of an association of ecological producers. In these cases, relationships may be coordinated by stricter but informal agreements on prices and volumes, and by production planning to ensure a diversified supply of products to satisfy consumer demand. Participation in these channels may also involve entry fees and requirements on attending assemblies and meetings of cooperatives and eco-fairs. In contrast to the value chain of system Type II, quality assurance is undertaken through social control and internal audits in the associations of ecological producers supervised by the SAG and by internal audits on eco-fairs. Quality attributes include certified organic production, local production, health, food security and sustainability. Trust, open information, sharing of power and transparent and systematized decision-making processes are commonly found in this value chain.

Consumers linked to system Type III are mostly urban with diverse backgrounds, including consumers mainly belonging to medium to high socio-economic income groups, and consumers involved in neighbourhood and social networks and cooperatives. Main purchasing criteria of these consumers include safety of products, and notions of sustainability in agricultural production.

The value chain of the large, organic system (Type IV) is mainly constituted by sales to supermarkets. Other minor marketing channels include sales to specialized shops, restaurants, hotels and eco-fairs. Relationships between Type IV farmers and actors in specialized shops, restaurants, hotels and eco-fairs are diverse and mostly based on spot market transactions. On the other hand, there is high vertical coordination between Type IV farmers and supermarkets, which is regulated by commercial agreements on price, volume, frequency of delivery and quality. The terms in these agreements include fixed monthly or annual prices, delay in payments (30–90 days waiting period before payment), fee charged by the supermarket to the producer for the benefit of having market access known as 'rapel', shelf placement charges, fees for special promotions and discount for produce that deteriorates before it is sold (Faiguenbaum, Berdegué, & Reardon, 2002). Procurement is often done through distribution centres in Santiago or through regional distribution centres. Quality assurance in terms of organic production, size, texture, freshness and packaging is undertaken through a set of requirements imposed by supermarkets. On-farm annual audits are conducted by supermarket procurement officials to check compliance with the requirements. The high concentration of the retail translates into a weak bargaining power of farmers (Boitano-Contreras, 2011). Nevertheless, given that there is less supply than demand of organic products in Chile, Type IV farmers have some space to negotiate (Cid-Aguayo, 2011).

Consumers linked to system Type IV are mostly urban consumers that belong to medium to high socio-economic income levels. In contrast to consumers linked to system Type III, these consumers may be more motivated and driven by healthy eating.

The value chain of the large, conventional system (Type V) is constituted by the traditional marketing channel, the agroindustry, supermarkets and public purchases (for fresh and processed products). Medium-sized farms sell most of the production to wholesale intermediaries in the traditional marketing channel. Larger-sized farms (companies) deliver most of the production to the agroindustry, supermarkets, supplying companies that distribute to public institutions and the export market. Second class products are sold to wholesale intermediaries in the traditional marketing channel.

Relationships in the traditional marketing channel are similar to the ones found for system Type I and Type II. While power between farmers and intermediaries is also asymmetrical, in this system farmers have better selling positions in wholesale markets due to the larger scale of their operations and better marketing logistics. Relationships between Type V farmers and actors in the other marketing channels go either through intermediaries or are direct. Intermediaries are small-sized firms or big supplying companies that organize procurement networks of regional or national scope to buy the production of farmers that fulfil the quality requirements set by the agroindustry, supermarkets or by public procurement programmes. Direct relationships with the agroindustry rely on seasonal contracts in which technical and financial support can be provided (ODEPA, 2018a). The direct relationships with supermarkets are similar to the ones that are established for system Type IV and include: fixed prices, delayed payments, 'rapel' charges, shelf placement charges, promotions fees and discounts for shrinkage and waste. However, quality attributes differ and focus on the size of vegetables, colour, firmness, texture, freshness, postharvest shelf-life and packaging. As products of system Type V are not certified as organic, supermarkets impose food safety requirements that in terms of pesticides focused on proper storage and disposal of pesticides, use of authorized products only, and compliance with the pre-harvest interval (the so-called waiting period) on farms.

Consumers linked to system Type V belong to any socio-economic income level. Buying requirements of these consumers are mainly price and the aesthetic quality of products.

4.4. Support structures

The main characteristics of the support structures associated with each vegetable food system Type are summarized in Table 5.

The small, conventional/traditional system (Type I) is supported by formal education centres and public research centres such as the Agricultural Research Institute (INIA). Moreover, a large percentage of farmers in this system Type are supported by the public platform of instruments and programmes of the Ministry of Agriculture delivered by the Institute for Agricultural Development (INDAP). The most important instruments and programmes are credit and public funding of private agricultural advisory services (e.g. programme of local development – PRODESAL, technical assistance services – SAT, and the indigenous territorial development programme – PDTI). Knowledge transfer on pesticides mainly focuses on proper application and disposal (i.e. adoption of safety measures, use of registered pesticide products, adequate use of equipment, and proper disposal of empty containers). In some cases, it includes the implementation of Good Agricultural Practices (GAP) and Clean Production (CP) agreements. Technical assistance on pesticides is also provided by input supplying companies. The instruments and programmes of INDAP show an evolution beyond agricultural production and technological development and nowadays incorporate issues of human capital development and market access facilitation (Aguirre, 2012).

In contrast to system Type I, the small, agroecological system (Type II) and the small, organic system (Type III) are mainly supported by NGOs such as the Centre for Education and Technology (CET) and a wide range of grassroots networks and social movements such as the Chilean network of agroecology and sustainable consumption, the Free Seeds Network, the Chilean agroecological movement (MACH) and the Agroecological Movement of Latin-America and the Caribbean (MAELA). Recently, the

Table 5. Summary of the main support structures by vegetable production system type and its associated value chain.

Characteristics	Type I	Type II	Type III	Type IV	Type V
R&D	Formal education centres and public research centres (e.g. as INIA)	NGOs, alternative research centres and grassroots networks and social movements (learning by-doing).	NGOs, alternative research centres, grassroots networks and social movements (learning by-doing)	Private research centres and learning by doing. Formal education centres and public research centres (marginal).	Formal education centres and public research centres (e.g. INIA).
Extension services	Extension financed primarily by INDAP and delivered by private, academic and civil society institutions. Technology Transfer Groups (GTT) of INIA. Technical advice input supplying companies Pesticides: extension focused on management and disposal of pesticides, GAP and CP agreements.	Grassroots knowledge sharing systems, NGOs, and alternative research centres. Extension primarily financed by INDAP and delivered by private, academic and civil society institutions. Technology Transfer Groups (GTT) of INIA Public extension in agroecology is marginal.	Grassroots knowledge sharing systems, NGOs, alternative research centres. Public extension by INDAP in organic agriculture is marginal.	Private extension with a demand-driven approach and input sellers providing technical advice.	Private extension with a demand- driven approach + technical advice input supplying companies. Technology Transfer Groups (GTT) of INIA. Pesticides: extension focuses on pesticide efficiency, GAP and CP agreements.
Innovation policy	Public policies, programmes and funding through INDAP.	Innovation mainly comes from grassroots networks and social movements. Limited public policies, programmes and innovation in agroecology and commercialization.	Law on organic production/ Innovation comes from grassroots networks and social movements. Limited public policies specific to organic production and commercialization.	Law on organic production. Public innovation agencies and development programmes (FIA, CORFO, etc.) but no specific for organic production and commercialization.	Public policies Ministry of Agriculture (FIA) and the Ministry of Economy and Development (CORFO) (not specific for the vegetable sector).

Type I: Small, conventional/traditional system; *Type II*: Small, agroecological system; *Type III*: Small, organic system; *Type IV*: Large, organic system; *Type V*: Large, conventional system. *GAP*: Good Agricultural Practices; *CP*: Clean Production.

+++ means very strong/very high, ++ means strong/high, + means moderate/medium, +/− means limited/low, − means lack of/very low.

Federation of Agroecology and Responsible Consumption was also created. These grassroots networks and social movements mobilize resources and contribute to knowledge construction and capacity building of the actors involved, based on learning by doing rather than formal scientific approaches. It is worth noting, however, that there are ongoing conflicts between actors in Type II and Type III systems coming from the definition of the terms ecological agriculture, agroecological agriculture and organic agriculture and a perceived lack of communication between initiatives within these two systems.

To a lesser extent, system Types II and III are also supported by public institutions such as INIA (e.g. research and technology transfer groups on agroecology and organic agriculture); the Foundation for Agricultural Innovation (FIA) (e.g. consultancies, innovation projects and technological tours in organic agriculture); the Corporation for the Promotion of Production (CORFO) (e.g. funds to co-finance organic certification) and the INDAP, through the National Agroecology Committee (only for system Type II) and the instruments that directly or indirectly support agroecology, organic production and short marketing channels (e.g. organic SAT, courses and workshops and PRODESAL groups with an agroecological or organic focus). System Type III is also supported by the Law No. 20089 of 2006 (SAG-MINAGRI) on organic production which also supports system Type IV. Nevertheless, there is limited public support and little development of public instruments to support organic and agroecological production (Pino, López, Salazar, Torres, & Uytewaal, 2017). As one of the interviewees stated: *'There has never existed a policy on organic agriculture. Basically, the current Law is a quality regulation to ensure that the product sold as organic is effectively organic'*.

The large, organic system (Type IV) and the large, conventional system (Type V) receive support from formal education centres and public research centres such as INIA. However, the support is marginal for the system Type IV. Financially, support is mostly provided by the platform of public programmes and instruments supporting the agricultural sector. These programmes and instruments are managed by the Ministry of Agriculture through FIA and the Ministry of Economy through CORFO (e.g. suppliers development programme – PDP, partnerships projects for development – PROFO, Innova Chile). Technical assistance at the production level for both system Type IV and Type V follow a demand-driven approach that is responsive to the needs of the farmers. Technical assistance is mostly provided by private national or, for the larger companies, international advisors. Technology transfers groups of INIA also provide technical assistance. With respect to pesticides, technical assistance focuses on increasing pesticide use efficiency as strategy to reduce costs and attain higher productivity levels. In some cases, technical assistance includes the implementation of GAP and CP agreements. Public institutions and input supplying companies provide technical assistance in handling and disposal of pesticides.

4.5. Food system performance

Here we present the expert assessment of the current performance of the five vegetable food system types in terms of social welfare, economic performance, environmental protection, and food and nutrition security. Individual scores attached by experts to each statement are provided in Appendix 4.

Regarding social welfare, experts attributed medium to high performance to systems Type III (small, organic) (scoring on average 3.7) and Type II (small, agroecological) (scoring on average 3.5) for the society statements. These systems were considered to have supportive and inclusive value chains that provide opportunities for all actors and encourage consumers to know where the food comes from. Contributions to society of systems Type I and Type V were given the lowest scores (scoring on average 2.0 and 2.9 respectively), caused by high power asymmetries between actors, lack of fair working conditions, and promotion of 'anonymous' food. System Type IV (large, organic) was given medium to high social performance (scoring on average 3.3) (Figure 2).

In terms of economic performance, expert assessment showed best performance for system Type V (large, conventional) (scoring on average 3.8 out of 5) and Type IV (large, organic) (scoring on average 3.7). Experts considered these systems economically profitable and having high levels of productivity. Least economic performance was attributed to food system Type I (small, conventional/traditional) (scoring on average 2.4). In addition to low profitability, economic benefits of this system were considered to be poorly distributed among food system actors (Figure 2).

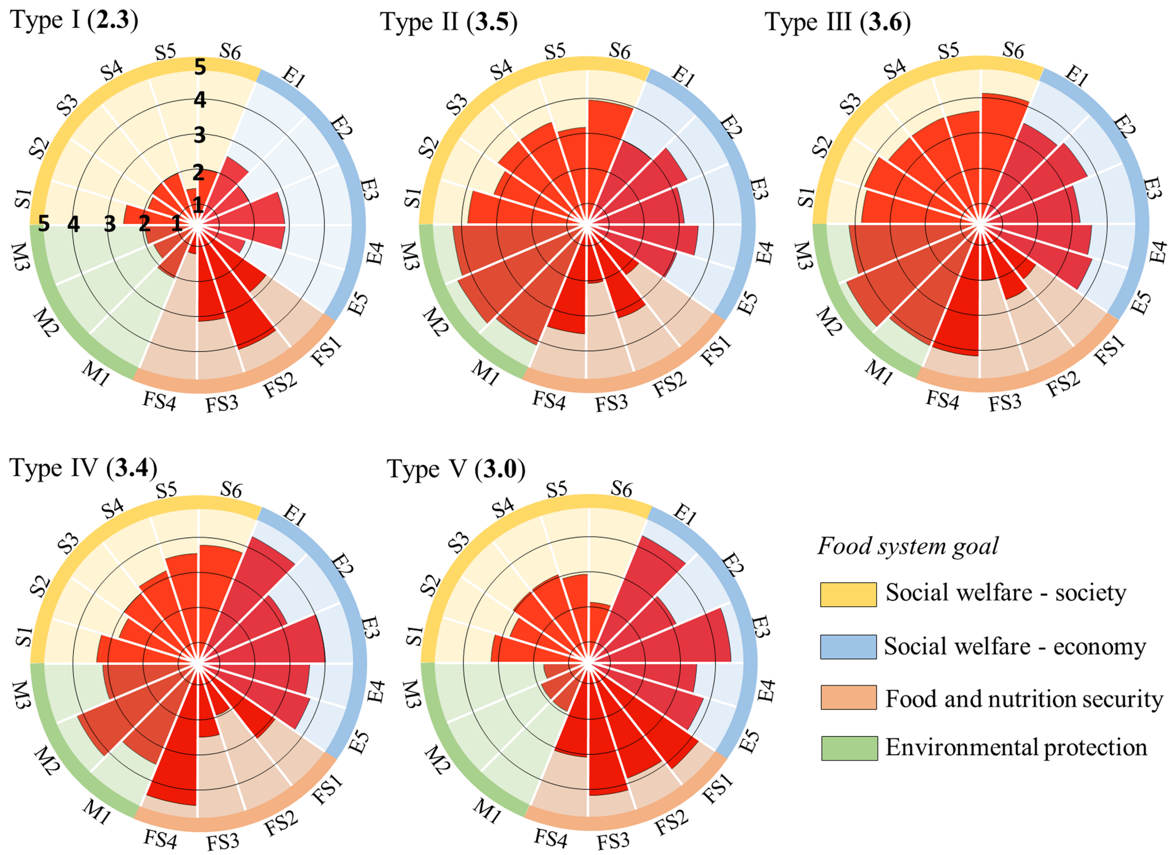

Figure 2. Stakeholder assessment of the perceived current performance of vegetable food systems. The further the wedge reaches towards the outside line, the better the performance of the food system in relation to the statement described in Appendix 1. *Type I*: Small, conventional/traditional system; *Type II*: Small, agroecological system; *Type III*: Small, organic system; *Type IV*: Large, organic system; *Type V*: Large, conventional system. Bold numbers indicate average performance scores for each of the four food system goals based on a five-point Likert scale, where 0 represents a strongly negative performance and 5 a strongly positive performance.

In terms of environmental protection, experts attributed high to excellent performance to systems Type II (scoring on average 4.3) and Type III (scoring 4.4 on average). These systems were considered to promote farming practices that maintain the integrity of the natural system and that minimize negative impacts on the environment. Least performance was attributed to systems Type I and Type V (scoring on average 1.9 and 1.8, respectively), Food system Type IV was given medium to high performance (scoring 3.6) (Figure 2).

Regarding food and nutrition security, stakeholders attributed high performance to system Type V (scoring on average 3.9), and medium performance to all other systems (Type IV scoring on average 3.0; Type I 2.9; Type II and Type III 2.8). Reasons for the medium performance assessment differed among systems. Type IV was considered to provide limited access and affordability to the Chilean population. Medium performance for Type I resulted from lack of controls to ensure the provision of safe vegetables. Main reasons for medium performance of systems Type II and Type III were a currently insufficient and discontinuous supply of vegetables and a lack of ubiquitous outlets (Figure 2).

Overall, stakeholders assigned the highest average performance score to food system Type III (scoring 3.6), followed by system Type II (scoring 3.5) and Type IV (scoring 3.4). Worst overall performance was shown for food systems Type V (scoring 3.0) and Type I (scoring 2.3) (see Appendix 4).

4.6. Classification of vegetable food systems into dominant, alternative or hybrid food systems

The indicator 'market share in terms of volume' provides a proxy of the level of alignment of the different vegetable food systems to the Chilean agri-food regime.

The traditional marketing channel and the supermarkets, which are mainly associated to the small, conventional/traditional system (Type I) and the large, conventional system (Type V), commercialize almost 100% of total volume of vegetables in Chile. Wholesale markets have a share of 80%, of which most passes through Lo Valledor (Boitano-Contreras, 2011; Econometrics, 2012; Schwartz et al., 2013), which is the wholesale market where most farmers (Type I and Type V farmers), intermediaries and vendors in commercial and mix street markets meet. Supermarkets have a volume share of around 20%. Although their participation in volume is still relatively small compared to the traditional marketing channel, supermarkets are becoming an important player in the Chilean food industry (CODEMA, 2015; Faiguenbaum et al., 2002).

There are no official statistics of the market share in terms of volume for the small, agroecological system (Type II), the small, organic system (Type III) and the large, organic system (Type IV). Nevertheless, a very small share can be inferred by looking at the number of farmers in each of these system Types relative to the total number of farmers. According to the INDAP (2017), no more than 1.4% of its users (i.e. approximately 1,800 smallholder farmers) are categorized as agroecological (Type II) farmers. INDAP users encompass approximately half of all smallholder farmers (INDAP, 2016) and therefore the number of agroecological farmers may be underestimated. Production and commercialization of organic vegetables are in a budding stage. In 2017, the area cultivated with certified organic vegetables was 370 ha or 0.5% of the total production area (ODEPA, 2018b). There are about 100 small organic (Type III) farmers, associated in 10 producer organizations that certify the products through a PGS (ODEPA, 2018b) and no more than 10 business-organic (Type IV) farmers that certify organic production through a third-party certification system.

Based on the indicator volume market share, vegetable food systems Type I and Type V can be classified as dominant systems. As the technological and organizational characteristics of systems Type II and Type III deviate radically from those found in dominant systems, these systems can be classified as alternative systems. Vegetable food system Type IV incorporates and combines infrastructure, practices and actors of the dominant systems. Some of their technical and organizational innovations (e.g. organic certification and labelling) can be considered as incremental adjustments to the dominant systems. Therefore, although the market volume of vegetables in this system is small, this system could be classified as a hybrid system that is close to the mainstream.

5. Potential of the vegetable food system types in view of sustainability transitions based on EI

Tittonell (2014) and Gliessman (2015) conceptualized change towards sustainable food systems that rely on EI through five levels of change[4]: Level 1 reflects the dominant approach to food and farming adhered to under the productivist paradigm. Level 2 consist of the optimization of practices in conventional systems to increase efficiency and reduce the use of environmentally damaging chemical inputs. Level 3 refers to the substitution of conventional inputs with those that are less harmful for the environment. Level 4 expresses the redesign of farming systems using EI concepts and practices. Level 5 is the more advanced stage for actually achieving the sustainability transition. It implies a shift in the current agri-food regime towards a regime configured around the wider principles of sustainable production and rural development. The transition pathway to sustainable food systems is not a linear process. Changes can start at or overlap at different levels (Gliessman, Putnam, & Cohen, 2017; IPES-Food, 2018).

We explored the current levels of food system change by mapping the Chilean vegetable food system types onto the five-level framework (Figure 3).

Systems Type V and Type I, based on the small and large conventional farms, respectively, mapped primarily onto Level 1 with their focus on production of standardized products embedded in current market configurations. Their objectives, especially for system Type V, focused on increasing productivity and economic gains, which was corroborated by the expert assessment of food system performance (see subsection 4.5). Sustainability improvements in these systems were mostly targeted at increasing

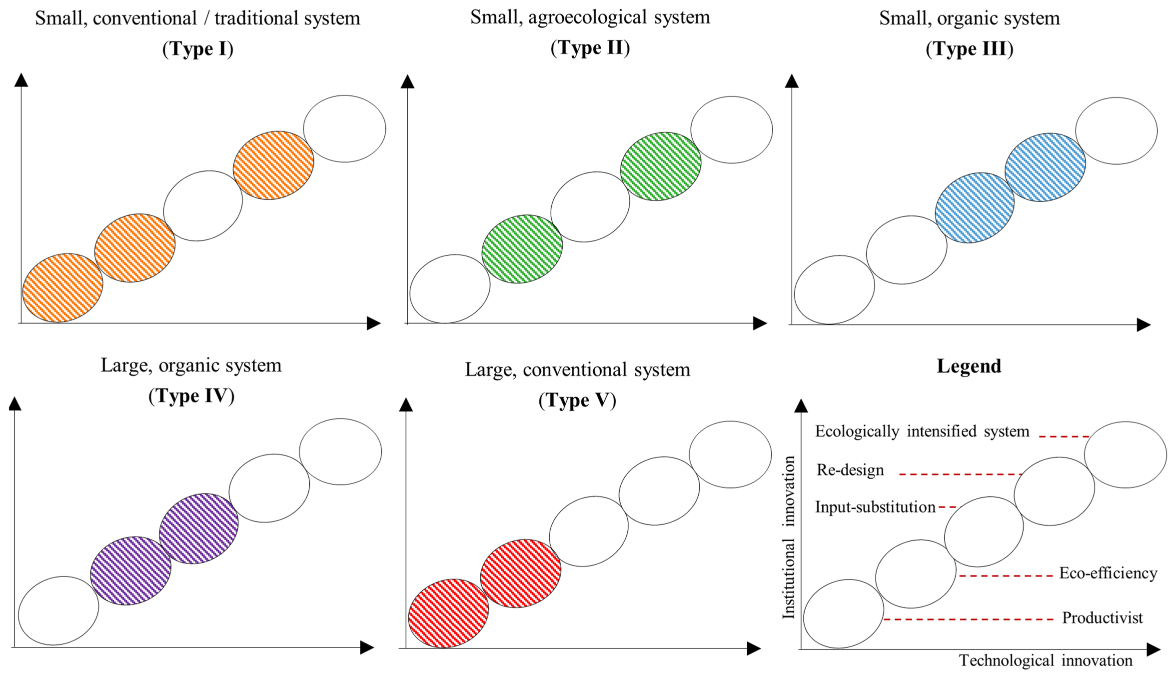

Figure 3. Levels of change towards sustainable food systems relying on EI, and potential of the vegetable food system types to support such a transition (taken and adapted from Tittonell (2014) and Gliessman (2015)). Each oval represents one level of change towards sustainable food systems. Level 1: current productivist system; Level 2: (eco) efficiency; Level 3: input-substitution; Level 4: redesign; Level 5: shift towards a new agri-food regime. It is worth noting that the trajectory is not necessarily linear and, therefore, a food system type may overlap for different levels. The closer a vegetable food system type to the right-side of the figure (coloured pattern in the oval), the higher its potential for a transition given the level of both technological (e.g. crop rotation, diversification,) and institutional/organizational (e.g. collective decision-making, 'new' markets, social networks) innovations.

efficiency in terms of reducing inputs of pesticides and fertilizers per unit output, reducing costs and maximizing outputs, i.e. moving from Level 1 to Level 2. As Plumecocq et al. (2018) pointed out, these improvements, especially for system Type V, imply an update of the conventional model of agriculture, which is based on chemical inputs, to a technology-intensive model that seeks to reach its weak sustainability objective via technological improvements (*sensu* Horlings & Marsden, 2011). System Type I was also found at Level 4. In some cases, this system Type has redesign characteristics at the farm level coming from traditional and indigenous farming practices that are supportive of EI.

Type IV, encompassing the large organic farms, mapped onto Level 3. This type catered to niche markets based on certified organic production, in many cases based on large-scale monocultures and substituting industrial agriculture methods by organically allowed ones. This type has been denoted as the conventionalization of organic systems (Darnhofer, Lindenthal, Bartel-Kratochvil, & Zollitsch, 2010) or 'greenwashing' of conventional farming (Lamine & Dawson, 2018), while at the same time being more ecologically and socially acceptable (Lamine, 2011; Mier y Terán Giménez Cacho et al., 2018; Therond et al., 2019). This type is compatible with the biological input-based (biotech) model of agriculture (Plumecocq et al., 2018), which prioritizes economic performance coupled with values of health care and environmental protection (see subsection 4.5).

Current transition pathways of food systems Type I, Type IV and Type V do not challenge the paradigm and values that shape the industrial approach to food and farming. They implement incremental adjustments in the systems either to reduce harmful environmental effects and satisfy consumer demand. Nevertheless, in the long run, incremental sustainability adjustments may constitute steps towards a transition based on EI (Mier y Terán Giménez Cacho et al., 2018; Pretty, 2018).

A transition to sustainable food systems based on EI shows more promise for food systems types at Level 4. Type II and Type III, based on the small agroecological and organic farms, respectively, overlap at this level. The potential of these systems was corroborated by the expert assessment on food system performance (see subsection 4.5), which showed that these systems can better balance the multiple food system goals. Type II featured both efficiency in the use of conventional pesticides and fertilizers 'where needed' and redesign characteristics that come from a wide range of agroecological principles. Type III on the other hand comprised input substitution for pest control and fertilization, and redesign characteristics, such as crop rotations, diversification and ecological infrastructure that allow reducing dependence upon external inputs.

In both Type II and Type III, EI at the farm level was supported by institutional and organizational innovations that include: (i) increased autonomy of food system actors in production and commercialization; (ii) horizontal decision-making and coordination in collective forms of organization such as agroecological communities, PGS groups and eco-fairs; (iii) peer groups for sharing experience in agricultural production and marketing; (iv) support by a wide range of grassroots networks and social movements; (v) emergence of alternative food networks that favour high frequency of direct relations between producers and consumers, reduce power asymmetries within the value chains and provide more transparent marketing channels in terms of information for all actors (e.g. prices, volumes) and consumers when compared to systems Types I, IV and V.

These innovations meet most of the preconditions for an agroecological transition at the scale of the agri-food system. These preconditions include: changes in production practices to incorporate EI; changes in knowledge generation and dissemination; changes in social relations in the form of new shared values rooted in nature, transparency, equity and ethical production and consumption; new or favourable markets; and changes in the institutional framework that set the conditions and incentives for a transition process (IPES-Food, 2018; Magrini et al., 2019; Mier y Terán Giménez Cacho et al., 2018). However, the results of our diagnostic study showed how these systems remain still relatively small and localized and have limited impact on the agri-food regime. This was reinforced by their limited share of market volume expressed in the currently insufficient and discontinuous supply of agroecological and organic vegetables and a lack of ubiquitous outlets. These systems received little economic and institutional support in comparison to the dominant systems; had little representation at the policy level; and did not receive support from dominant value chains such as the traditional marketing channel that favour standardized products and economies of scale. Internally, we found a perceived lack of communication between initiatives in Type II and Type III systems and conflicts between their actors on the definition and perusal of the terms ecological agriculture, agroecological agriculture and organic agriculture in the Chilean law.

Supporting a transition to more sustainable vegetable food systems based on EI requires actions to effectively remove current transition barriers, both related to interactions of these alternative systems with the Chilean agri-food regime and within the alternative systems. Research and policy may support scaling of the emergent systems by acting on the urgency to re-think food systems beyond measures of food system performance, such as productivity and economic returns, which often does not take into consideration environmental, social and food and nutrition security goals (De Schutter, 2017; Flores & Sarandón, 2004; IPES-Food, 2016); highlighting successful small agroecological and organic initiatives, for example through agroecological 'lighthouses' and Campesino a Campesino models (Nicholls & Altieri, 2018) to show the feasibility of practices to farmers in system Type I that still hold traditional farming practices supportive of EI; developing a protocol to differentiate agroecological from organic products, which is still lacking in Chile and; combining Type II and Type III systems with longer value chains such as the public food procurement and school feeding programmes of JUNAEB, which might be a way to favour their scalability. Caution should be paid, however, to the importance of 'right-scaling' of operations rather than always trying to adopt the 'bigger is better' philosophy.

6. Limitations and further research

In our study and given the availability of information, elaboration of the food system typology and assessment of food system performance was elaborated based on a qualitative assessment of a limited number of variables (some of them yes/no variables), simplifying the complexity of vegetable food systems and hiding the fuzzy and overlapping spaces among the system types.

Although the selection of variables commensurate with the qualitative nature of the typology, which revealed salient diversity of food systems, the diagnosis presented here could be deepened by:

i including the whole set of inputs (internal and external to the system, e.g. nutrients derived from parental materials, organic matter breakdown and technology used), and non-conventional outputs (e.g. ecosystem services).
ii using quantitative information to adjust the typology and allow complementary studies based on life cycle assessment (LCA) or emergy analysis (see for example Rótolo, Francis, Craviοto, and Ulgiati [2015]).
iii assessing to which extent the vegetable food system types may overlap and complement each other as multiple transition pathways can be based on a combination of elements from different food systems (hybridization) (Plumecocq et al., 2018). Such analyses are needed to guide evidence-informed economic and innovation policies towards socially and environmentally more inclusive development pathways.

7. Conclusions

We applied the framework developed by Gaitán-Cremaschi et al. (2019) to describe the diversity of co-existing Chilean vegetable food systems and explore their potential to contribute to a transition to sustainable systems based on ecological intensification. Our analysis shows considerable diversity in this regard and five food system types. On the one hand, transition pathways to sustainable food systems may stem from the productivist paradigm, based either on eco-efficiency (food system Type V) or an input-substitution approach (food system Type IV). These pathways are advocated by actors in dominant food systems that implement incremental innovations, mainly in the form of technological improvements to reduce harmful environmental effects and satisfy consumer demand for green products. On the other hand, more radical transition pathways may be supported by actors in alternative food systems that aim at a transformative redesign of food systems with a basis on EI. We found combinations of eco-efficiency and re-design (food system Type II) as well as input substitution and re-design (food system Type III).

Whichever the sustainability transition pathway, there are trade-offs to be considered between the multiple food system goals (Mockshell & Kamanda, 2018), as reflected in our assessment on food systems performance. Addressing these trade-offs requires going beyond the limited narrative for assessing food systems based on productivity and economic gains that reinforces the dominant systems and excludes alternative options (De Schutter, 2017; Flores & Sarandón, 2004; IPES-Food, 2016), towards a better balance between the multiple economic, environmental, social, and food and nutrition security goals, as evidenced in our results.

Notes

1. Law 20089 from 01/17/2006 of the Chilean Ministry of Agriculture establishes that only farms that are certified in accordance with the Chilean regulations in organic production can be called agroecological, ecological or biological. Although small agroecological farms are not certified, in practice they apply the principles of agroecology in farming.
2. In comparison to farmer's markets that are totally constituted by agricultural producers, merchant and mix street markets are dominated by merchants, who act as intermediaries between producers and consumers.
3. Consumer groups are not widespread in Chile. The few examples include La Cosecha de Rancagua in the region of O'Higgins, La Canasta in the Metropolitan region and La ManZana in the region of Los Lagos.
4. Gliessman (2015) define the levels of food system change when conventional food systems are converting to agroecological-based food systems.

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Disclosure statement

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