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Navigating agroecological transitions: key factors for Bolivian small producers

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This paper presents the learnings from a study that used qualitative research methods to explore how to promote agroecological transitions (AETs), conducted over four years with Bolivian farmers and consumers in Cochabamba. The study examines how different motivations and production practices shape farmers' engagement with agroecology. The research applied thematic analysis to construct farmer typologies and identify factors influencing perceptual and behavioural transformation towards AE practices. The results show three farmer typologies based on motivations and production practices: i) conventional production and offer; ii) mixed production and offer; and iii) AE production and offer. Thematic analysis identified a set of primary and secondary factors common across typologies that affect transformations towards AE, with the main factors including risk-aversion, plot size and family tradition, and secondary ones such as health and new AE knowledge versus family tradition. A gap emerged in how these factors affect changes in perspectives and behaviours across farmer types. Understanding the role of context-specific factors in AE transformations is essential to improve AE training and implementation approaches, and the discussion interprets farmers' risk perceptions through behavioural economics, particularly Prospect Theory, which highlights loss aversion and reference-dependent decision-making.

KEYWORDS

agroecological practices, agroecological transformations, Bolivia, farmer typologies, farmers' motivations

1 Agroecological transitions and the Latin American experience

Agroecology (AE) is now recognised as a transformative approach to sustainable agriculture, although it has its origins in Indigenous and local practices. This section synthesises the features of AET experiences in the Latin American region. It illustrates historical developments, driving and limiting factors and policy implications to contextualise our study.

Historically, in Latin America, AE is rooted in indigenous farming practices, including varied cropping systems, soil health, and balanced relationships with nature (Altieri and

Nicholls, 2017). Nevertheless, the region has been subject to, among others, environmental deterioration and land concentration that have promoted the gradual increase of export-oriented monocultures (Altieri, 2004).

In this paper, AETs are understood holistically to include the multilayered changes needed, more or less simultaneously, for small-scale farmers (Tittonell, 2019) to accomplish shifts in perceptions, attitudes and agricultural production practices. AETs involve transformations at different scales, from individual farmers to their farms, the wider community (including consumers), the surrounding landscape and the institutions associated with the agricultural system (Tittonell, 2019). AE is a viable alternative to conventional agriculture, which is rooted in mono-cropping, the use of chemical fertilisers and pesticides, and oriented towards maximising production and profitability (Dale, 2020). While higher yields and profits are desirable goals for small-scale farmers, conventional agriculture causes much damage, such as the negative effects of chemical fertilisers and pesticides on soil, local fauna and human health (Altieri and Toledo, 2011; Holt-Gimenez et al., 2008).

Socioculturally, conventional agriculture approaches often label local indigenous knowledge 'backwards', thus endangering its preservation by aggressively replacing it with technological innovations stemming from the Green Revolution (Altieri, 2004). Moreover, mono-culture (mono-production, mono-knowledge) – aka homogenization – practices make farmers more vulnerable to socio-environmental disruptions and disasters.

According to Tittonell (2019) AET model, AETs occur gradually, but non-linearly, through different stages. Namely, by i) optimization of management practices to increase productive efficiency, ii) inputs substitution, iii) the redesign of the system. A driving force to transition to stages one and two is consumer demand for healthier products that promote the preservation of local knowledge and cultural traditions. Consumers' cultural beliefs, norms and values, and appreciation for environmental sustainability, play an important role in determining their demand (Tandon et al., 2021). Studies have shown that motivations for consumers' demand for organic[1] products also include the health benefits attached to their consumption (Pishbahar et al., 2020). Therefore, consumer demand combined with changes in regulations – such as the requirement of specific certifications like the Participatory Guarantee Systems (PGSs)[2] or the organic labels – can support achieving input substitution[3].

An increased demand for organic and AE products in a context where trustworthy relationships between producers and consumers are highly valued has been another incentive for farmers to adopt AE approaches (Kaufmann et al., 2023). Specifically, Kaufmann et al (2023) study describes five examples of Participatory Guarantee Systems (PGS). In Mexico, there are three: Tianguis Orgánico Chapingo, Tianguis Alternativo Tlaxcala, and Tianguis Alternativo El Pochote Xochimilco; in Chile, there is the Ecoferia de la Reina; and in Bolivia, there is the ECO Feria. All are specialised markets that offer food under the PGS system.

Latin American countries count various examples of AET experiences. In Brazil, AE movements succeeded through the emergence and growth of social rural movements – such as the Landless People's Movement (MST, Movimento dos Trabalhadores Rurais Sem Terra) – promoting more equitable land distribution and sustainable agriculture to counter neoliberal and conventional approaches and to promote food security and sovereignty (Cohn et al., 2006; Petersen et al., 2013). In Argentina, AE practices have been adopted by smallholder farmers and promoted by local movements like the Union of Land Workers (UTT, Unión Trabajadores de la Tierra) in response to economic pressures and environmental concerns, leading to improved soil health and increased biodiversity (Parodi, 2018). In Ecuador, like in other Andean countries, the element of trust has been central to its social economy, which relies on the concept of social capital – as a practice where the relationship between consumers and producers and their transactions mutually influence and reinforce each other (Deaconu et al., 2021). In Guatemala first and in the rest of Central America after, Holt-Giménez (in Cohn et al., 2006) explains, the Campesino a Campesino movement represents a farmer network where knowledge exchange and solidarity against the ills of oppressive systems of production promote the preservation of traditional and sustainable practices. In Mexico, CEDICAM (Centre for Integral Campesino Development of the Mixteca) has centred their work around the role of native seeds and local traditional knowledge to promote sustainable agricultural practices for food sovereignty locally and abroad (Dahl-Bredine, 2006). Similarly, in the Yucatan state of Mexico, the Slow Food movement responded to the damage caused by chemical fertilisers and hybrid seeds. Slow Food supports locally produced food and local knowledge and traditions, yet it lacks government support (Blanco-Gregory et al., 2020). Differently, in Nicaragua, AETs have been supported by state policies, although in the context of a hybrid approach to agricultural production. External funders and local civil society actors have strengthened their networks, within which the National Movement of Agroecological and Organic Producers (MAONIC) has played a central role in the development of AE at the national level and in influencing policy-making. Furthermore, the role of women at the forefront of the movement has made the aspect of gender equity particularly prominent in the region (Christina et al., 2021; Dorrego Carlón and Bottazzi, 2025; Mestmacher and Braun, 2021; Schiller et al., 2020). In Bolivia, where our study was conducted, AE is described as having a 'long' and a 'short' trajectory (Catacora-Vargas et al., 2017). Within the former, indigenous agricultural methods connected local communities' livelihoods with their natural surroundings, where ecological conservation and the transmission of social and cultural traditions coexisted with a

1 In this context, this statement can be applied to agroecological products in the same way as for organic ones.

2 Participatory Guarantee Systems (PGS), according to the national technical standard of Law 3525, are an alternative certification system suited to the Bolivian context, as they provide an economically viable option that is both culturally and economically acceptable, ensuring the quality of ecological products for consumption in the national market.

3 The third stage, system redesign, requires concurrent changes among consumers, producers, institutional and policy arrangements, together with other stakeholder organisations involved in the value-chains (Tittonell, 2019).

productive agricultural system (Catacora-Vargas et al., 2017). The latter is akin to the processes that occurred in other countries in the region in response to the environmental and sociocultural degradation resulting from the Green Revolution. The Suka Kollus Program (PROSUKO) – which promotes the preservation of indigenous knowledge – and the AGRECOL Andes Foundation – which supports the creation of local ecological markets (see the section on 'Context' for more details about AE in Bolivia) are among the institutions that contributed to the spread of AE in Bolivia.

AE implementation and scaling up in Latin American countries still face various challenges, despite gradual steps over time. Limited access to land, resources, and technical support (Rosset, 2008) are among the main factors that hinder the spread of AE practices among small-scale farmers.

AE's scalability and its wider spread are hampered by state policies promoting the interests of agribusiness and agro-exports and restricting funding for AE-related research and extension services (Giraldo and McCune, 2019). AETs require a policy framework and institutional arrangements that facilitate them (Al-Kaisi and Lal, 2020). Agrarian reforms to redistribute land and resource ownership can contribute to empowering smallholder farmers and supporting them in implementing AE practices (Altieri et al., 2012). Additionally, investing in participatory and farmer-led research and extension services, together with incentives to promote AE products in markets, can strengthen the growth of AE farming approaches (Altieri and Toledo, 2011).

Important developments have taken place to advance AE across the Latin American region.

However, issues related to socio-economic inequities, institutional shortcomings and environmental degradation associated with dominant conventional approaches remain to be addressed (Zimerman, 2024). To further food sovereignty and more sustainable food systems, Latin American countries require joint efforts across multiple stakeholders, including researchers, grassroots and activist organisations and policy-makers.

1.1 Producers' behaviour

Latin American producers' behaviour towards AETs is influenced by common factors across countries. Several common factors can be identified: access to information and training, the availability of labour, land tenure arrangements, and the size of the agricultural holding (Mendez et al., 2017; RIMISP, 2024); social capital, particularly in the form of collective action, together with access to markets and marketing chains (Meijer, 1998; Altieri and Toledo, 2011; RIMISP, 2024; Carrasco et al., 2024); perceptions of risk and prior experience (Altieri and Toledo, 2011); as well as the broader socio-political context and prevailing local culture (Altieri and Toledo, 2011; Mendez et al., 2017; Sabourin et al., 2018; Meijer, 1998). Chilean AE farmers' wishes, for instance, included the need for more labour, maximising profits and increasing soil health (Potocnjak Rivas, 2014).

Some producers may label all products as organic and charge higher prices even when they are not produced organically (Ward et al., 2004) to increase profits, and there is no traceability system for consumers to check. Farmers protect income security also through income diversification strategies to avoid risk and reduce farm production vulnerability. They may introduce AE practices in parallel to conventional farming or other profitable activities to ensure a secure household income (van der Ploeg, 2008). This pattern can be interpreted through Prospect Theory, which proposes that decision-makers evaluate outcomes relative to a reference point rather than in absolute terms. Potential losses are weighted more heavily than equivalent gains, so actions that promise a 'sure' avoidance of yield loss, such as preventive pesticide use, become attractive even when they involve known health or environmental costs (Kahneman and Tversky, 1979; Pan et al., 2020).

The desire to increase the production of commercial crops and to secure profits has been at the centre of the decision to use chemical pesticides by small farmers in the region (Nicholls and Altieri, 1997; Bravo and Ferrin, 2003). RIMISP (Centro Latinoamericano para el Desarrollo Rural) studies have highlighted that the desire to increase commercial crop production and secure profits is a central factor in small farmers' decisions to use chemical pesticides in Latin America. Small-scale farmers often resort to chemical inputs to enhance yields and meet market demands, despite the associated health and environmental risks (RIMISP, 2011). Furthermore, analyses of agroecology and territorial development indicate that economic pressures and the need for profitability frequently lead to continued reliance on chemical pesticides, hindering the adoption of agroecological alternatives (RIMISP, 2024). These findings align with broader regional trends, where the pursuit of economic gains often takes precedence over environmental and health considerations, reinforcing the cycle of pesticide dependence among small farmers (RIMISP, 2024). A comparative study of the use of chemical pesticides in Nicaragua and Costa Rica explains that they have been increasingly utilised not only by larger farmers focused on mono-cropping, but also by smaller farmers, with negative effects on multiple levels and inequitable distribution of the benefits and costs for their use (Thrupp et al., 1988). Studies conducted in Ecuador, Bolivia and Peru have also identified that the adverse consequences of pesticide use have been worsened by their use in incorrect doses inadequately recommended by retailers (Struelens et al., 2022). The consequences of an incorrect recommendation can be catastrophic, as demonstrated by the infamous case of banana workers in several Central American countries who were exposed to the nematicide DCBP (Nemagón) in the 1980s. This product not only caused widespread infertility, but also cancer and other chronic ailments, in a scandal marked by the concealment of information about its toxicity by the manufacturers (Ramírez and Ramírez, 1980). Akin to Latin American farmers' behaviours, a study conducted in Indonesia on the impacts on farmers of local integrated pest management (IPM) showed that despite them knowing the adverse health effects of pesticides, their risk-aversion and concerns about economic losses prevented them from changing their practices (Kishi, 2002).

2 Context

The project and study that this paper draws on were conducted in Cochabamba, Bolivia (Figure 1). Cochabamba is a medium-sized city with 2 million inhabitants[4]. It is located in an inter-Andean valley, primarily focused on dairy farming and agriculture. The most commonly produced crops are potatoes and other tubers in the highlands, and corn and vegetables in the valley. Summers are short, hot, and mostly cloudy; winters are short, cool, and mostly clear. Throughout the year, temperatures generally range from 4 °C to 26 °C. The climate is fairly dry year-round, with an annual rainfall of 300 mm, concentrated between November and March (Navarro and Maldonado, 2002). The valley's production is sold at farmers' markets and popular fairs, from where it is also distributed to the rest of the country through transporters and wholesalers. Popular fairs are peri-urban spaces where producers arrive directly to sell to wholesalers in the early morning and to the final consumer throughout the day. This is why prices are affordable and they are popular with middle- and low-income families. AE food prices are sold in 80% of cases at the same price or lower than conventional food (Alem et al., 2018).

After an exploration of several fairs in the region based on specific criteria for selection – namely, existing permanent AE offers and sales stalls, and farmers' willingness to be involved in the project – seven popular fairs were selected. We focused our work on local fairs with the aim of strengthening the democratisation of access to AE foods for low- and middle-income sections of the population, countering the notion that such foods are only accessible to people or families with high incomes. The criteria for selecting these fairs were: that they be established fairs within a specific geographic area (Kanata Metropolitan Region), that they host AE producers with a permanent supply, and that the consumers correspond to a low- to middle-income level. These included: Quillacollo, El Playón, and Apote in the Municipality of Quillacollo; Loa in the Municipality of Tiquipaya; Villa Obrajes in the Municipality of Sacaba; and Las Rieles and Primero de Mayo in the Municipality of Cercado. However, the project worked in five of the seven popular fairs (Quillacollo, El Playón, Apote, Loa and Villa Obrajes). In Las Rieles fair, no AE farmers with a permanent offer at the fair were found. In the fair Primero de Mayo, the AE farmers' group already had other institutional support so they did not work with us (Figure 1). The objective was to strengthen the AE offer in five popular fairs through the exchange of experiences among farmers and AE training events.

Training events' topics included AE pest management, bio-inputs' preparation and use, sales tips, food's nutritional components and effects of the use and consumption of pesticides. The study also tracked changing agricultural practices, motivations and AETs during the intervention.

In Bolivia, particularly in the Interandean Valleys and the Altiplano, AE production was promoted through training provided by institutions and municipal governments, with two fundamental objectives: to (i) generate commercial alternatives for agricultural products, and (ii) guarantee the food sovereignty of farmer families in a context of climate change. AE production can contribute to accessing and consuming a diversity of healthy foods and promoting better nutrition, as income generation is directly related to market access (Deaconu et al., 2019).

The National Agricultural Census (2013) indicates that 95% of the agricultural production units (APU) correspond to family farming and that AE farming is carried out mainly by family farming and hunter-gatherers (Instituto Nacional de Estadística (INE) Bolivia, 2016; MDRyT and Fundación AGRECOL Andes, 2018). Therefore, AE farming is implemented mainly by small farmers and, within these, it is mostly in the hands of women (Llanque et al., 2018; Lindemann et al., 2024). The majority of them are unpaid workers, which puts them at a great disadvantage compared to men, although there is a slight increase in women classified as self-employed (Tito-Velarde, 2021). Rural women invest more effort in generating their economic income, which they complement by selling their labour force as agricultural labourers, so often their main obstacle is a lack of time (Llanque et al., 2018).

Although much progress has been made in policies and regulations on paper since 2006, in reality, deforestation has increased, and the relative value of small products has fallen compared to agro-industrial ones. Likewise, successful AE-to-organic production cases are fractional, reflecting the difficulties of scaling AE in Bolivia (Terán, 2020). Finally, a study in Cochabamba reported 6,200 farmers with organic production, who contribute only to 2,1% of the food production there (26.050 tn), and only 0.02% of their production had the accreditation of the PGS (Alem et al., 2018; Fundación Agrecol Andes, 2018). This shows that the regulatory progress since 2006 has not induced an increase in AE production with PGS in Cochabamba.

3 Methodology

This study used a qualitative approach, including semi-structured interviews and observations in combination with a classification rubric used to identify categories of farmers that apply pesticides (coined "Conventional"; 100% reliance on these inputs), partially apply pesticides (coined "Mixed"; less than 100% of reliance on these inputs), and not apply pesticides (coined "Agroecological", 0% reliance on these inputs). We aggregated farmers into these three groups to better understand their motivations, AE practices and AET processes.

Notably, this study did not employ the Tool for Agroecology Performance Evaluation (TAPE) because it focuses on the performance of various criteria of agricultural and food systems (Mottet et al., 2020). Differently, this investigation explored farmers' perceptions and experiences in their AET process to understand how and what local factors motivate or hinder them. In doing so, we connected the experiences shared by participants with Tittonell's steps to AETs (Tittonell, 2019) outlined in section 1. The focus was on comprehending the nature of the AET processes taking place without rigorously assessing their AE performance in the way that the TAPE tool does.

4 https://cpv2024.ine.gob.bo/index.php/resultados/resultados-demografia-demografia/resultados-demografia-poblacion/

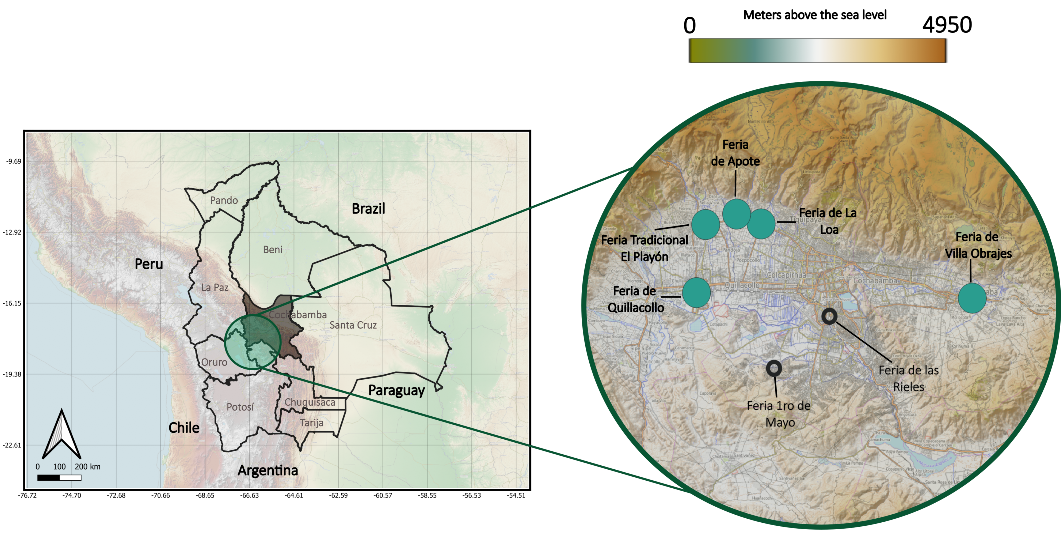

FIGURE 1
Geographical location of popular fairs. On the left, it is the map of Bolivia with its departmental boundaries. Names of the departments are in light grey and surrounding countries are in black bold. The department of Cochabamba is highlighted because it was the department where popular fairs were studied. The light green circle shows the area of research. On the right, the light green circle indicates the approximate area of the location of the popular fairs, and the empty circles show the two fairs where no intervention was done with AE producers. In the background, we included a gradient of colours to show the intervalley with lighter colours and the dark brown shows the area with higher elevations.

This approach was in line with our research interest in learning from local experiences how to improve AET interventions in the context.

3.1 First stage

In the first stage, semi-structured interviews were conducted with 30 farmers to delve into their practices, motivations, and knowledge gaps, so that the design of the intervention strategy could be based on the information gathered in this first phase. They were contacted through agronomist colleagues from the AGRECOL Andes Foundation. Six interviews were in-person and 24 by telephone, due to the incidence of COVID-19, and they were recorded but not transcribed in their entirety, with only the testimonies relevant to the research topics extracted verbatim. The interviews covered general information about the farmers (see Interview Template in Appendix 1). Data was organised into Excel spreadsheets and then analysed using thematic analysis. Codes were assigned to the relevant interview transcripts and then organised into categories. The structure of and relationships among categories helped develop themes (Braun and Clarke, 2006).

The 13 AE production practices evaluated were adapted from the chart by Altieri and Rosset (1996). Farmers were asked if they carried out the AE practices and it was confirmed in their plots in person. The original table was supplemented with practices related to pest and disease control and management, which were already recognised as a bottleneck in food production, particularly in AE production (Table 1).

3.2 Second stage

The classification rubric to determine the typology of producers at the seven markets was conducted on the scheduled dates, with 416 participants in 2021 and 411 in 2023. The classification rubric contained three questions: i) What do you produce?; ii) To what crops do you apply pesticides?; and iii) In what percentage? Following this, all were invited to join the project activities; however, the majority were agroecological (AE) producers, and work focused primarily on them[5].

The AE typology consists of farmers with PGS accreditation and those we have called self-declared. For the second stage, four practices were prioritised for more intensive promotion: ground cover, crop rotation, crop association, and the use of bio-inputs[6]. An initial evaluation of these practices was conducted in 2021 with 38 producers and a follow-up evaluation in 2023 with 36 producers, as reflected in Table 2.

As a first step, we aimed to identify the types of producers present at the seven popular markets (conventional, with mixed production, ecological, or other). This was achieved through a survey that included questions such as which foods they produced, whether they used pesticides and/or fertilisers, the proportion of ecological versus conventional production, seasonality of their offerings, and whether they had a fixed sales stand, among other relevant aspects. Data were collected at two points: (i) between April and May 2021,

5 Conventional farmers did not wish to participate in the study.

6 Biol, phosphites, mountain microorganisms, sulfocalcium broth and ash broth.

TABLE 1 Practices evaluated in the initial investigation of the study.

Nr.	Production practices	Grouping of practices into themes
1	Crop rotation	1. Promotion of soil biotic activity
2	Manure	
3	Mixed cropping	
4	Compost	
5	Use of own seeds	2. Seed use
6	Stubble	3. Soil conservation and irrigation water management
7	Irrigation water management	
8	Minimum tillage	
9	Fallow	
10	Cover Crops	
11	Mineral broths	4. Control and management of pests and diseases
12	Use of biol and microorganisms	
13	Fermented preparations	

TABLE 2 Participants in the capacity-building process.

Participants in the capacity building process	2021	2023
Self-declared AE	23	25
AE with PGS	15	18
In AE transition with mixed production	0	3

from 416 farmers, and (ii) between July and August 2023, from 411 farmers. Data were compiled from producers offering fresh vegetables and organised in Excel spreadsheets.

Once the typology of producers at each market was established, all were invited to participate in the capacity-building activities offered by the project. This group consisted of approximately 46 producers (Table 2).

The group was predominantly composed of AE producers, among whom actions were promoted such as peer recognition, differentiation of sales stands, training workshops, and follow-up visits. Workshops and experience exchanges focused on AE practices, bio-input production, health risks associated with agrochemicals, strategies to improve sales, and the nutritional composition of foods. Four AE practices were prioritised: ground cover, crop rotation, intercropping, and five bio-inputs with high impact on soil and plant fertility. These AE practices were evaluated through a baseline assessment in August 2021 and a final assessment between January and July 2023. The baseline was conducted using a pre-established form on the SurveyMonkey website[7]. The final assessment focused on production practices, farmers' motivations for their chosen production methods, and their experiences with their own AE processes. It also included conversations with participants to explore their perceptions of improvements in production, sales skills, and market dynamics, following a thematic guide during visits to the farmers' plots.

Thematic analysis allowed identification of farmers' motivations for AE production, as well as the key factors ultimately determining their production methods, through partially transcribed interviews supported by detailed field notes and complete audio recordings.

7 https://www.surveymonkey.com/

Initial codes related to agricultural decisions, motivations, and constraints were developed and grouped into themes. These themes were subsequently synthesised into distinct typologies representing groups of farmers with shared behavioural and contextual characteristics (see Section 4, Results).

Participants in the baseline and final interviews are shown in Tables 2 and 3.

3.3 Data analysis

Data from interview notes was interpreted using thematic analysis to establish key themes. The latter were determined through an iterative process of coding, categorisation, and cross-analysis of data to establish the patterns of relationships among various themes (Emerson et al., 1995; Ladany et al., 2012; Maguire & Delahunt, 2017). Through this process, 3 main farmer typologies were identified and are presented in the results section below, together with the major factors and motivations that positively and negatively influenced farmers' perceptions and practices towards AETs.

We performed Fisher's test to compare the three different typologies identified and also between the different years of implementation of the project. We used the R software (version 4.5.2) to perform the statistical analysis.

3.4 Ethical considerations

Four dimensions of research ethics requirements were considered: (1) information, (2) utilisation, (3) consent, and (4) confidentiality. These requirements ensured a good relationship between researchers and participants and prevented any conflicts (Vetenskapsradet, 2024).

Informed consent was obtained from each participant verbally. Verbal consent helped avoid generating distrust, as requiring a written informed consent could have raised suspicions of participants' further responsibilities. We did not use the term research due to its negative connotation among farmers in this community. They were informed about participating in a project to strengthen the AE offer through training and experience exchanges, and that together we would evaluate the final results.

4 Results

We present the results in 3 main sections: (i) Typology of farmers in the popular fairs, (ii) Typologies' motivations and practices and (iii) Factors that promote or hinder AETs.

TABLE 3 Methodological tools and target groups in research.

Stage one: Diagnosis of a sample of producers who offer their products at popular fairs		
Methodological tool	Objective	Target group
Semi-structured interview (2020)	Know the type of production, motivations and productive practices	Sample of 30 producers: 15 agroecological, 12 mixed and three conventional
Stage two: Capacity-building strategy for producers of popular fairs supported by the project		
Methodological tool	Objective	Target group
Classification rubric (2021)	Know the typology of producers at fairs	All producers who offer fresh vegetables and tubers at fairs: 416 in 2021, 411 in 2023
Survey (2021)	Evaluate the implementation of four productive practices	Agroecological producers from fairs who participated in capacity building (with PGS and self-declared): 38 in 2021, 36 in 2023
Visits to the farm plots (2021 and 2023)	Identify changes in the plots (design, cultivated areas, promoted practices, others) and discuss the process of capacity building	46 producers participating in the capacity-building process (agroecological and mixed)
Participant observation at fairs (2021 to 2023)	Detect changes in producers, in their food supply and other items promoted through the capacity-building process, as well as changes in the market or among other participants in it	46 producers who took part in the capacity-building process (agroecological and mixed), as well as other participants in the fair
Guided interview (2021 and 2023)	Evaluate the motivations and perceptions of improvement in the production and dynamics of the fair.	Producers from fairs who participated in capacity building (AE with PGS, AE self-declared and mixed): 38 in 2021, 36 in 2023

4.1 Conventional production and offer

Conventional farmers apply pesticides and synthetic fertilisers in all their production and offer these foods for sale at fairs. It is the largest group, covering on average 53% of the total number of farmers at the seven fairs. From our sample, we found that 50% of men and 50% of women were the ones grouped under this category of production. Regarding commercialisation, we found that 93% of women were in charge of this activity in this category.

These are producers whose production is entirely market-oriented. Most specialise in one crop, such as tomatoes or potatoes. Others have a slightly greater diversity, but they still only grow a few crops on large areas of land, mostly between 5 and 10 hectares.

Their concern is ensuring a good harvest, and thus their marketing and income, which motivates them to use agrochemicals. These producers generally have some knowledge of the effects of agrochemicals on health, but they believe it is impossible to produce without their use.

4.2 Mixed production and offer

Mixed farmers apply pesticides and/or fertilisers during periods of increased pest and/or disease incidence or to ensure the production of their most economically important crops. This means they do not apply them to all their crops or all the time, but they do use chemical inputs. This is the second largest group and represents, on average, 24% of all farmers. In this group, 54% of women dedicated their activity to production, while 98% of women in this group were dedicated to commercialisation.

The crops of greatest economic importance are usually grown on the largest plots and are primarily intended for sale. The plot sizes in this group ranged from 1 to 5 hectares. Foods grown around the home are mostly left unsprayed and are intended for family consumption.

Notably, this group, in addition to using agrochemicals, often prepares and applies various homemade remedies (based on ash, lime, sulphur, detergent, or fermented mixtures of garlic, onion, and locoto, among others). Many also apply other soil amendments, such as vegetable compost. Their main concern, as with conventional producers, is protecting their crops from disease. However, their strategies tend to be more integrated and diverse, taking into account not only pests but also soil health and plant condition.

4.3 Agroecological production and offer

AE farmers do not use synthetic pesticides or fertilisers in their production processes and sell their AE produce at local markets. Collectively, they represent 14% of all farmers. Within this category, we found that 84% of women dedicated their time to production, while 100% of women were dedicated to commercialisation.

Most report having received support primarily from NGOs through training on the preparation of bio-inputs aimed at pest and disease management and soil fertility, including biol, sulphur wash, Bordeaux mixture, microorganism capture, bokashi, and phosphites, among others. Their cultivation plots are generally small, ranging from 50 m² to 1 ha.

4.4 Other typologies: 9%

The producer typology revealed three small groups resulting from combinations of the previous categories:

i. Ecological production, mixed supply (7% of all producers). These are producers who farm agroecologically, prioritising family consumption. Surplus produce is taken to the market, where they also purchase and resell food typically produced conventionally, i.e., using agrochemicals.
ii. Ecological production, conventional supply (1% of all producers). These producers reserve all their AE production for family consumption and purchase and resell conventionally produced food at the market. This group only appeared in the final survey (2023).

iii. Mixed production, conventional supply (1% of all producers). These mixed producers allocate all their AE production to family consumption and take their conventional production to the market. This group only appeared in the initial survey (2021).

4.5 Typology: motivations and production practice

The graph in Figure 2 below shows the implementation of different AE practices by farmer typology. The asterisk with the horizontal bar indicates that a Fisher's test has found a significant difference between the two proportions signalled by the line. Note that the bar is sometimes omitted when the percentage is zero.

4.6 Conventional: motivations, production and offer

Conventional farmers are focused on the implementation of five AE practices out of a total of 13, mostly inherited from family tradition, such as stubble, the use of manure, crop rotation, fallow and water harvesting (Figure 2). The latter is driven by the droughts recorded in recent years, strengthening traditional irrigation shifts or structures, such as shortcuts or dams. These farmers have an approximate range of between 5 and 10 hectares of land, and their production practices go hand in hand with monoculture production and large areas. Therefore, the practice of fallow is very strong in this group (Figure 2). Typical examples are corn, potatoes, tomatoes and paprika, which are the crops of greatest economic importance and are those that are commercialised.

Conventional farmers in this study focus primarily on ensuring production, which they achieve through practices such as manure application, crop rotation, and fallow, but also through the regular use of synthetic agrochemicals. They consume part of their harvest, yet their production decisions are strongly oriented toward sales and income generation. What distinguishes them from AE farmers in our typology is not only the reliance on external inputs but also the absence of practices aimed at enhancing on-farm biodiversity, ecological regulation of pests, or community-based principles that are central to AE.

4.6.1 Soil fertility perception

These farmers are motivated to apply agrochemicals because they perceive that soil fertility is very poor, alleging "the land is tired", that there are crops that no longer produce without agrochemicals (such as potatoes, tomatoes, watermelons, among others).

4.6.2 Pests and diseases

These farmers also perceive that the attack of pests and diseases on large plots of land requires effective and immediate actions, such as the application of chemical pesticides.

Some of their perspectives are illustrated below:

> "Everything produces with agrochemicals; if you don't fumigate, it doesn't produce well" (Conventional male farmer, Totora).

Some farmers are aware of the health effects of agrochemicals but consider it impossible to produce without the use of chemical inputs:

> "Actually, we don't hear much about AE farming, because here it doesn't produce well anymore if you don't use agrochemicals, no matter what you have to put (…) Yes, I know they (agrochemicals) don't do us good, but it's like a necessity that must be done no matter what, because if you don't put it, it doesn't produce. It's not for our pleasure that we're filling the product with chemicals, and I know it's all chemicals that we're consuming, because in the past it was produced naturally, but it couldn't be produced in any other way." (Conventional female producer, Omereque)

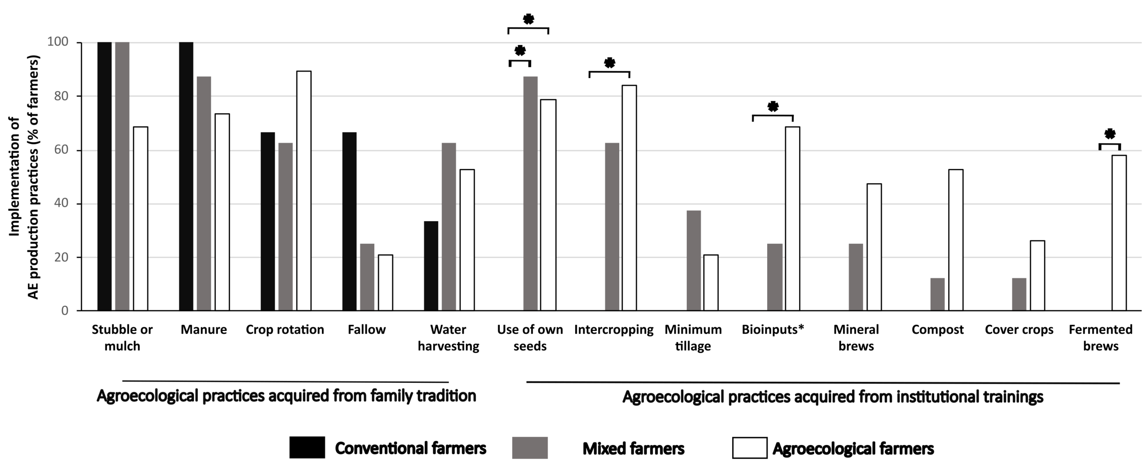

FIGURE 2
Implementation of AE production practices by farmer typology.

Such statements illustrate reference-dependent evaluations: farmers appear to judge outcomes relative to an income or yield target, and the perceived 'certainty' of loss prevention outweighs the uncertain future benefits of AE practices (Kahneman and Tversky, 1979).

4.6.3 Lack of knowledge

Other farmers made comments that display their lack of knowledge of the impact of the use of agrochemicals related to health, water, the environment or the soil:

> "I don't think jampi (herbicide) is poison, it just kills weeds. Nothing happens with the other jampis either (insecticides or fungicides)" (Conventional male farmer of Azul Qhocha, Totora).

4.7 Mixed: motivations, production and offer

Mixed farmers also implement practices inherited from family tradition. More than 60% implement manure, fallow and water harvesting (Figure 2). They justify the application of agrochemicals by low soil fertility, large-quick fixes and crops that simply need pesticides, like conventional farmers.

However, compared to conventional farmers, they have less investment in production, particularly in the purchase of external inputs and machinery, relying instead on family labour and locally available resources. Although they do not provide a specific percentage, the families report that their priority is to produce enough to meet their own household consumption, whether from their ecological or conventional production, and to sell any surplus at the markets. The other practices are applied by less than 40% of the mixed typology, including fallow, since their lands are generally smaller than those of conventional ones.

Among the foods produced mainly for household consumption and therefore not fumigated are vegetables such as lettuce (*Lactuca sativa*), slipper gourd (*Cyclanthera pedata*), spinach (*Spinacia oleracea*), onion (*Allium cepa*), and herbs such as celery (*Apium graveolens*), parsley (*Petroselinum crispum*), and mint (*Mentha* sp.), as well as many fruit trees, generally located around houses and in small plots. When these same foods are market-oriented, these crops are grown in monoculture and therefore tend to be sprayed and fertilised. In addition to agrochemicals, many mixed farmers make and apply homemade preparations based on ash, lime, sulphur, and detergent, as well as fermentations based on garlic (*Allium sativum* L.), onion, and bell pepper (*Capsicum annum* L.). Making more IPM (integrated pest management) is also motivated by the economic savings that this generates. They make other amendments to the soil, too, such as the application of vegetable compost and manure, making crop management more comprehensive. Their main concern, like conventional farmers, is to protect their crops from diseases, but their measures are usually more comprehensive and diverse, considering not only the pest but also the soil and the plant.

Many of them sell what they have left over from family consumption, although their main activity is resale. A small portion of them only take what is left over from their family consumption, and therefore, they only go to the fairs when they have a surplus and are not permanent there.

Three mixed farmers actively participated in the activities of the project; all were motivated to train and reduce the use of agrochemicals in their production and participated in all the workshops and exchange visits.

The motivations for the production practices implemented by this group include: i) securing economic income; ii) savings in production costs; and iii) family health.

4.7.1 Securing economic income

One of the main motivations of mixed farmers is to secure their economic income through cash crops that sustain their family economy. As one farmer explains, not using agrochemicals can constitute a financial risk:

> "Eh, the main reason [for applying agrochemicals to his production] is that since we have large plots of land, it is that in an ecological way we can maintain the balance a little, but it also causes us losses when we do not use pesticides. When we use pesticides it's safer, let's say, because it's an income that we have from our crops. In large crops I did the test, but the truth is that it hasn't gone well, I would have to build greenhouses, because outdoors it doesn't work, mainly tomatoes, the tomato is eaten by bugs if you don't apply pesticides, it totally finishes it, totally, it's the main reason (…) For the tomato, it is applied three times a week, mainly insecticide, fungicide as a prevention we just apply" (Mixed male farmer, conventional offer, Municipality of Saipina).

This evidence underscores reference-dependent evaluations, whereby farmers assess outcomes against an income or yield benchmark, with the perceived assurance of loss avoidance taking precedence over the uncertain prospective benefits of agroecological practices (Kahneman and Tversky, 1979).

4.7.2 Savings in production costs

A mixed farmer, who produced only the AE portion for his family consumption and the commercial crops conventionally, decided to prepare the five bio-inputs promoted by the project, in addition to implementing green manures within the tomato and broccoli beds that are his main commercial crops, with broad beans and peas. He was the first farmer to develop and implement all the practices promoted, motivated by concerns about his family's health and to reduce the high costs of agrochemicals. In the final interview, he said that, according to his estimate, particularly with the application of bio-inputs, he managed to reduce 40% of his production costs by ceasing to buy agrochemicals. He managed to control the major pests of tomato and broccoli, but failed to control the tomato moth, so he continued to apply an insecticide (Imidan) and a micronutrient for that.

4.7.3 Family health

Motivations regarding family health are related to the fact that most mixed farmers have previously participated in projects in this area or are currently participating in a training process, as part of the project, and they know that the application of agrochemicals 'is not good for health':

> "Some say it's not harmful, but I see that if we fumigate the production is good, that is, it's producing by force. I eat agroecologically, my community is agroecological. But the surrounding communities are not. For the market, it doesn't need to be eco-friendly; they (consumers) don't care. If you want to sell, you want to get as much as possible, don't you?" (Mixed male farmer with PGS, Municipality of Totora).

This typology includes farmers who were previously conventional and felt the effects of the application of agrochemicals on their health. Several growers, mainly those within the PGSs, have experience in the application of agrochemicals, and they claim that in doing so they felt burning eyes, a burning face and other symptoms, or others have a family history of allergies, cancer, lupus and other diseases, and believe that they are related to the use of agrochemicals, so they have stopped using them or at least moved from being conventional to being mixed, prioritising AE products for family consumption. Farmers often report acute symptoms from pesticide exposure, including burning eyes, skin irritation, and headaches (Ncube et al., 2011; Sapbamrer et al., 2024), while reviews confirm direct ocular toxicity (Jaga and Dharmani, 2006). Long-term exposure has also been linked to cancer and autoimmune diseases such as lupus and rheumatoid arthritis (Parks et al., 2022; Shekhar et al., 2024; Gatto et al., 2021).

In the words of some of the farmers interviewed:

> "I apply very little [agrochemicals], because that's how the land is taken care of" (Mixed male farmer, Loa Fair).

> "I try to produce naturally, but due to lack of time, I buy chemical products" (Mixed female farmer, Apote Fair).

> "I spray [with chemical pesticides] only when it gets sick" (Mixed female farmer, Apote Fair).

> "I spray once in the whole cycle, no more" (Self-declared AE female farmer, Primero de Mayo Fair).

In this group, too, there is misinformation regarding the use and effects of agrochemicals, mainly on health, soil, and water:

> "I apply a product to kill ants [agrochemical], but it's not serious because it doesn't affect the plant or the soil" (Mixed female farmer, Ex Rieles Fair).

4.8 Agroecological: motivations, production and offer

The initial investigation revealed that AE farmers implemented all the practices evaluated. More than 50% implemented 8 practices, and between 26% and 47% implemented the remaining 5 practices. The practices that are least implemented are fallow because this group has the smallest plots and minimum tillage (Figure 3). Furthermore, agricultural work in the cultivation of mainly vegetables traditionally involves turning the soil. Their production is primarily oriented towards family consumption, which motivates them not to use agrochemicals and to diversify their production by combining more crops. Hence, family consumption orientation constitutes a motivation to be AE.

Their AE practices include the use of manure from animals such as cows, sheep, rabbits, chickens and pigs, and the use of vegetable compost, also inherited from family tradition. To manage pests and diseases, they use preparations of plant, animal and mineral origin such as potassium soap, sulphur or calcium sulphide broth, Bordeaux mixture, biol, and bocashi. Some mention other preparations such as water with lime, powdered ash, powdered lime, water with detergent, water with chlorine, humus, and macerated garlic, bell pepper, onion and even beer in slug traps, noting that they have a wide variety of bio-inputs and that their focus may be more on the plant than on the soil. In general, they do not see their production as an investment but rather as something secondary to their main income.

As mentioned in the section on methods, the AE typology consists of farmers with PGS accreditation and those we have called self-declared. Although both groups began with similar percentages of implementation in production practices (except for the bioinputs), towards the end of the study, the percentages of implementation of the self-declared ones noticeably increased (from 25% to 77%), whereas the PGSs increased only slightly (from 1% to 32%). This phenomenon is explained by the fact that the PGSs have institutional support from which they receive technical training, and they already had prior knowledge about the production practices evaluated. Therefore, they did not increase noticeably like the self-declared ones, who did not have institutional technical support until the beginning of the research. It is important to note that self-reported implementation of practices may be influenced by social desirability bias, particularly among self-declared farmers who could

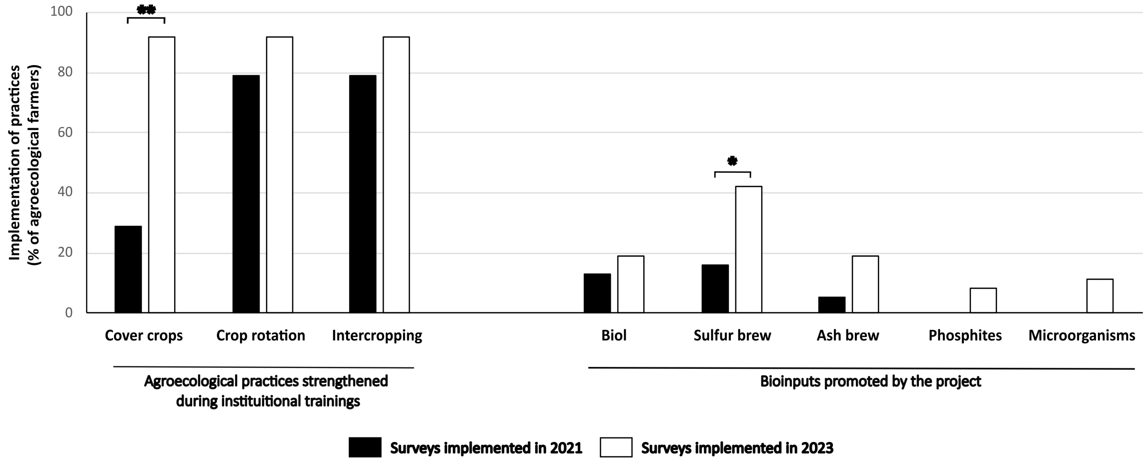

FIGURE 3
Changes in the implementation of AE practices in AE farmers, between 2021 and 2023.

have felt greater pressure to demonstrate progress during the study period. Consequently, the possibility of social desirability bias influencing self-reported adoption rates, particularly among the self-declared group, should be considered when interpreting these results (Kaine and Wright, 2024).

The practices where there are fewer differences between them are those inherited from family tradition, such as crop rotation, manure, intercropping and use of own seed (Figure 2). Of the 4 production practices prioritised in the work with AE farmers – plant cover, crop rotation, intercropping and five bio-inputs (i.e., biol, phosphites, mountain microorganisms, sulfocalcium broth and ash broth) – the practice that has increased the most after the intervention was soil coverage, from 29% in 2021 to 92% in 2023, followed by bio-inputs, as reflected in Figure 3. About soil coverage, a female farmer explained:

> "I used to throw away the cover, then I burned it, and then I tried to do the compost, but I didn't leave a single stick in the field, I didn't know everything I was losing" (PGS female farmer of the El Playón Fair).

Most AE farmers had some level of knowledge about the impact of agrochemicals on health, from which they derived their main motivation for producing agroecologically, but most were not aware of the advantages and principles that surround and underpin AE farming. Along with family consumption, health, aroma and durability, family economy, increased time with children, soil care, women's economic independence and family tradition constitute the motivations for AE farmers.

4.8.1 Family consumption

Family consumption and a diverse diet continue to be the main motivations of AE farmers. Women, who are housewives, grow a variety of foods, prioritising their families' nutrition, which also means savings on external food purchases.

4.8.2 Family health

Producers perceive AE production as an investment in health, not only in consumer health but also, and more importantly, in the health of their own families. This prioritisation is often linked to their awareness of the health risks associated with pesticide residues in food, which is informed by either personal health experiences or those of close family members.

Some of the AE farmers interviewed shared their reasons for choosing to produce agroecologically:

> "For the health, not only of my family but of others, because even people with cancer seek us out" (AE female farmer with PGS, Feria El Playón).

> "I like the garden. I de-stress, seeing the fruit of my work, seeing my family eat something natural and healthy from my land; it makes me happy" (Self-declared AE female farmer, Quillacollo Fair).

> "For health, so as not to tire the earth or kill its nutrients" (Self-declared AE female farmer, Loa Fair).

> "To avoid diseases" (Self-declared AE female farmer, Villa Obrajes Fair).

> "Because it's for my consumption, and my family's … Since I'm retired, it's my hobby, and also for mental, emotional and physical health." (Self-declared AE female farmer, Loa Fair).

4.8.3 Aroma and durability

In the same way, all AE farmers mentioned the importance of the better taste of AE food and its post-harvest durability, which allows them to preserve it in their pantry for longer.

> "This AE production, beyond the economic reward you may have, is that you know you are eating healthy, your family, your children are eating healthy. It's the greatest compensation. You go to your garden, harvest and eat … There's no such thing as not knowing where it comes from. A lady told me that broccoli from other places, her son didn't want to eat it. He smelled it, but this broccoli didn't have that smell, and her son eats it without a problem. We grow this way because it's one that you like, the contact with nature. It is a lot of work, exhausting. If you had a weeding on the weekend, you have to do it so that you don't get bugs, but you know that you are going to consume it healthy" (Self-declared AE female farmer, Quillacollo Fair).

4.8.4 Family economy

The economic aspect can be viewed from several angles. For some, it means "supporting the husband" in generating economic income; for others, it is about "spending less" by not using expensive agrochemicals and by not buying what they can produce for consumption, thus allowing them to save. Finally, for others, it is an "investment that must be recovered". Behind these factors, there is also the fact that more and more consumers are interested in AE food and that motivates them to continue producing in this way.

4.8.5 Increased time with children

Several female AE farmers mentioned that as farmers, they can spend more time at home with their children; otherwise, they would have to go out to work to help with the economic expenses of the household.

> "I worked in kindergarten before I had my children, but when I had them, what was I going to do? I had to give it up. So producing close to my house, because this is my mother's land, allows me to be more at home, with the children, and I also generate income that covers some expenses." (PGS AE female farmer, El Playón Fair).

4.8.6 Women's economic independence

In most cases, the most important family income is generated by the husbands (who work in gardening, as company workers, and taxi drivers, among others). However, when women speak, they refer to "my income" when talking about specific activities such as raising cows, renting lucerne, processing dairy, selling food, or producing AE food. With this income, they normally buy supplementary food, cover school expenses, clothing or others related mainly to the home and children. The latter denotes that they have decision-making power over that income and that it gives them economic independence and, therefore, greater empowerment.

4.8.7 Soil care

Some of the AE farmers feel co-responsible in caring for the soil and the environment in general, which motivates them to continue with this type of production. One of them explained:

> "From the workshop with chemists I understood that agrochemicals do damage above all to the soil, they kill the bugs, it kills them and it must leave them crippled, injured, surely so. Somewhat I imagine myself that way, and if we eat it, it also hurts us then." (Self-declared AE female farmer, Feria El Playón).

> "I like to take care of the land because with so many chemicals, all the insects, the bugs are dying, it's a healthy way to feed (…) I like to dig through the land, and I like to produce as I produce [agroecologically], going through the work of weeding and all those things." (Self-declared AE farmer, Quillacollo Fair, without a fixed stand).

4.8.8 Family tradition

Their families, from their grandparents, never applied agrochemicals, pesticides or fertilisers, and that is the way of producing that they learned.

Two female farmers of the El Playón Fair went from being mixed to being AE, after receiving the project's training, motivated by the value of AE food, its economic value, but mainly its importance in health.

Several farmers in this group have plots as small monocultures, particularly for tomatoes, lettuce, kale and others. This practice facilitates the management of the crop but brings them greater problems of pests and diseases. However, some farmers searched for information and natural products for the control of pests and diseases on their own. In the case of the tomato moth, they have bought Neem oil (*Azadirachta indica*) and special pheromones for this pest. In the process, some have been making interesting changes, such as better organising their properties to have more planting space or fruit trees. For pest and disease control, they also increased intercropping, such as mixed tomato production, by planting fava beans, peas and basil plants in the middle of their tomato.

beds.

4.9 Common factors across typologies

The factors that seem to be crucial in the adoption of AE practices and thus defining the typologies of farmers are (i) risk-aversion in their commercial production approach, (ii) the size of their land and (iii) family tradition.

4.9.1 Risk-averse commercial production approach

This is directly related to whether AE production is the farmers' main source of income or not, which in turn defines whether or not they will invest in it.

For conventional farmers, production is their business, as it is their only source of income, and they invest in it to earn.

The mixed ones need to ensure the commercial part of their production, and it is this part that they view as a business, but they also have a healthier production destined primarily for family consumption.

The AE ones see AE production as a secondary and complementary source of household income. Only for 5% of farmers (i.e., 2 farmers) it is their main source of income, but not the only one. The remaining 95% have other sources of income that are normally earned by the father of the family through the sale of his labour or in small family businesses. AE production gives them additional benefits such as food, health, childcare, and generating supplementary income for the family, which is particularly important for women.

Viewed through Prospect Theory, these farmers may be overweighting the probability of yield loss and are strongly motivated to avoid falling below their income reference point. This helps explain the preference for input-intensive strategies as a form of insurance (Pan et al., 2020).

4.9.2 Plot size

For all three groups, the size of their production land defines production planning and major agricultural practices. As mentioned previously, conventional and mixed farmers (their portion of land intended for sale) cultivate larger plots under a market-oriented monoculture system. Monoculture creates ideal conditions for the widespread use of pesticides, including crop uniformity, high vulnerability to pests and diseases, ease of mechanised application, and maximisation of both production and, consequently, profits. In contrast, agroecological and mixed farmers (the portion of land intended for family consumption) work on smaller plots with high species diversity, as they first meet their household needs and only then take any surplus produce to the market. In such highly diverse systems, each species requires different management, making pesticide application less effective, more costly, and less safe for the system as a whole.

4.9.3 Family tradition

From family tradition, farmers from all three groups inherited crop rotation, mulching and the application of manure, and fallow in the case of conventional ones. In AE farms, the habit of not applying agrochemicals strongly influences families.

5 Discussion

This study combines the experiences of conducting AE training and evaluations with farmers in five fairs in Cochabamba, Bolivia, over four years. These activities and interactions unravelled compelling learnings about the farmer typologies we encountered and the factors that influence their perceptions and practices. These learnings bear implications for approaches to AETs in Cochabamba and similar contexts.

The limited behavioural change despite knowledge of health risks is consistent with loss aversion and probability weighting. Farmers may overweight the small but salient probability of a severe pest shock, which keeps them anchored to a pesticide-based input bundle that feels safer than experimenting with AE practices (Kahneman and Tversky, 1979; Kemeze et al., 2020).

As presented in the results, the three main farmer typologies identified were i) conventional, ii) mixed and iii) AE. We found that their motivations for and factors affecting their production practices play a significant role in determining their typology and position within AE transitions.

Conventional farmers are primarily motivated by risk-aversion towards production and income generation. Several studies have shown that risk-averse farmers are more likely to use pesticides as a strategy to stabilise yields and secure income (Carpentier, 2017; Chèze et al., 2020; Pan et al., 2020; Su et al., 2022; Cai et al., 2024). Curiously, AE knowledge and awareness of the risks associated with the use of agrochemical pesticides and fertilisers for human health and soil quality do not appear to strongly influence their practices and, in some cases, their perceptions (Finger et al., 2022). At the same time, the adoption of certain AE practices is frequently rooted in inherited family traditions rather than in formal training to preserve soil fertility. This pattern is not limited to conventional producers, but is also evident among producers in the three categories, indicating that the transmission of agricultural knowledge through family networks plays a significant role across different production systems.

For conventional producers, however, family tradition is combined with the fact that their plot size is usually larger due to the prevalence of mono- and market-oriented crops, which determines the kind of AE practices implemented. Conventional farmers do implement AE management practices as suggested by Tittonell (2019) and other practices that need to be adjusted to facilitate AE transitions. This can have interesting implications for how AE innovations are designed and co-created, where acknowledging and taking advantage of the important role played by local traditions may positively influence the adoption of AE practices even among conventional farmers.

For mixed farmers, their risk-aversion and economic motivations are expressed through the use of chemicals when there is a higher danger of pests and diseases, and to ensure high production of commercial crops. At the same time, their plots being smaller than those of conventional farmers and including a priority for family consumption motivates them to implement more – but also different – AE practices that are inherited from family tradition and learnt from AE training. Different from conventional farmers who used AE practices due solely to family traditions and for better production, mixed farmers implement AE practices also for soil and human health reasons. About the AE transition model outlined above, the mixed farmer typology appears to be progressing towards input substitution. However, to further transform behaviours towards AE approaches, perceptions of risk-aversion remain to be addressed, as noted by Kishi (2002) in Indonesia, by demonstrating to farmers that reduced use of chemical pesticides does not equal reduced income (Kishi, 2002, p. 175). A study conducted in China is critical to our results. It concluded that factors related to perceptions of risks to profit maximisation contributed to decreasing farmers' pesticide use by demonstrating both the health and financial damages of excess use of pesticides (Pan et al., 2020).

As noted in the results, overall, AE farmers implemented all the AE practices included in the study. Their main motivation lies in the prioritisation of family health, while the factors that influence choices related to their production methods are that they are not concerned about the risks associated with commercial production, as agricultural production is not their main source of income and they have small-size plots, which are easily manageable using AE methods. Additionally, within this group, the role of women emerged as central for the implementation of AE practices, largely due to their prioritisation of family health. AE practices provided a means to enhance women's empowerment within the household by offering healthier food, time with children, and expendable income. At the same time, this central role could increase their workload and limit opportunities outside the household, illustrating the ambivalent effects of empowerment in the context of entrenched gendered responsibilities. The importance of the role of women in relation, for instance, to reduced pesticide use was found among Iranian female farmers, too, as compared to male farmers (Abdollahzadeh et al., 2016). Daza et al. (2020) state that in the development of AE in Ecuador, the role of women has been fundamental because they are in charge of caring for the production plots, as well as for the responsibilities of the home, tasks which primarily benefit the family environment since they reinvest the profits from their sales at fairs in improving the production system, as well as in the health and education of their children. Perez and Izurieta (2022) add that organisations of AE women farmers in Ecuador and Mexico have an important role in caring not only for the family and its individuals but also for the space they inhabit, the soil, water and air, as hopeful spaces that also have the strength to expand to society as a whole.

Our results showed that different percentages of women dedicated their time to agricultural activities depending on the category of farmers. Fewer women were involved in production activities in conventional farmers when compared to AE farmers. This trend also occurred when we compared the mixed farmer category and the AE category. This shows that when farming systems are more agroecological, at least from the farmers engaged in this study, the role of women is more prominent. Our study also revealed that when referring to commercialisation, the role of women is also more prominent regardless of the group of farmers. Future studies should focus on designing studies of gender to understand power asymmetries within the different systems.

Scientists and practitioners should pay more attention to addressing the gender imbalances identified in production and commercialisation. It is essential to push for gender-sensitive policies in AE that guarantee equitable access to subsidies, training opportunities, and research initiatives that fully recognise and value women's contributions. Such policies should not only improve women's access to productive resources but also strengthen their leadership and decision-making capacity within AE systems. At the same time, promoting the integration of care economy perspectives is key to acknowledging and alleviating women's unpaid care roles. Initiatives such as time banks, childcare services at markets, and community-based support systems can help redistribute care responsibilities, reduce women's workload, and enable greater participation in both production and commercialisation activities.

AE farmers encompass those with PGS accreditation and self-declared ones, and the practices they have in common are those related to family tradition, which plays an important role and influences their productive practices. This indicates that, in this group too, family traditions play an influential role. Moreover, this group also mentioned the importance of consumer demand in driving their production choices. Hence, this farmer group with their characteristics (i.e., PGS accreditation for some, self-declared for others, and the role of consumer demand) presents a position closer to the stage of input substitution in AE transitions (Tittonell, 2019). However, without institutional and policy support, this is only possible when AE production is not their main source of income, and it is unlikely to drive AE transitions at larger scales. This behaviour also aligns with livelihood vulnerability frameworks: where formal insurance, credit, or price support are weak, households rationally prioritise avoiding losses. Institutional gaps therefore, amplify loss aversion and contribute to the observed 'pesticide lock-in' (Scoones, 1998).

Blanco-Gregory et al (2020) found that greater assistance to producers was given by NGOs compared to the support of public authorities in the Yucatán region of Mexico for the promotion of AE ventures, such as facilitating distribution and sales channels. Similarly, farmers in our study feel abandoned by the state, and some of them self-organise to buy sales spaces with their funds without any state support to promote their products, sales spaces, or their sales themselves, apart from the assistance they receive from NGOs and the state university. This provision is not significant and, therefore, not enough. Additionally, NGOs' support is mostly directed at farmers with a PGS certification, but not at self-declared AE farmers, who are even more forgotten. In this regard, a study in China highlighted that using market incentives could help reduce the use of chemical pesticides by small farmers better than government regulations, such as higher prices for food produced without the use of pesticides, more stable marketing channels and markets in the medium and long term, and better information on consumer demand and the prices paid for safer products (Zhao et al., 2017). Another study in Ecuador concluded that strengthening the participation of small AE farmers in sales markets, as well as strengthening their organisations, are important factors in promoting the AETs (Borja et al., 2024).

Regarding the motivations for applying synthetic pesticides, Robinson et al. (2007) classify this practice into those who do not use pesticides, those who use them only before the pest attack, those who use them only after the pest attack and those who use them before and after. This classification goes hand in hand with the typologies in our study. Those who do not use pesticides are the AE ones, those who use them sometimes before or after are the mixed ones, and those who always use them before and after are the conventional farmers. Additionally, the factors that predispose them to use or not use pesticides are risk aversion, trying to minimise losses with their application, and the availability of cash. If a farmer has their cash or credit, it is expected that they would apply pesticides without hesitation. For Robinson et al. (2007), another factor is training. The more pest management training they receive, the more receptive they are to AE production practices. Different from our study, the typologies proposed by Robinson et al. (2007) highlight training as a fundamental factor for the farmers' receptivity to AE. In our study, instead, AE knowledge increase did not always result in the adoption of more AE practices. In self-declared AE farmers, this may be because they are dedicated to the production of diverse vegetables from different, generally short, cycles. For them, the main barriers are a lack of time, permanent technical support and availability of inputs or materials required to make preparations. As Levins (2006) remarked, agricultural producers' decisions depend on the purpose of production and, in the case of production for consumption, diversity and quality are prioritised. Concurrently, though, land productivity and workforce availability determine the size of the cultivated plot (Levins et al., 2006).

Another lesson in our findings is how chemical pesticide removal can be an entry point for AE transitions, by engaging in co-learning processes with farmers that include local traditions and context-specific characteristics (Belmain et al., 2022). Particularly, our results show that farmers with lower levels of risk-aversion and whose motivations (i.e., what they value) are focused on health are more likely to undertake AE practices.

The discussion above reveals that the farmer typologies in our study tend to focus on aspects of the AE transition process related to reducing the effects of chemicals in their production and implementing input substitution practices. A combination of their economic motivations, risk aversion, and external factors related to a lack of institutional support hinders their AETs from including aspects of systems redesign.

5.1 Further suggestions on how to accelerate AE transitions per group

The remaining question in this study is "what now?" Conventional, mixed and AE farmers all have specific requirements. In the case of conventional farmers, they require risk-mitigation tools at multiple levels. At the plot level, it might be necessary to provide access to improved varieties or decision support systems to reduce the use of pesticides, such as the hand-held decision support tool and PhytoAlert® to manage late blight (*Phytophthora infestans*) (Andrade-Piedra et al., 2025; Lucca et al., 2014; Pérez et al., 2024). In the case of mixed farmers, they need support in transitioning. This means that to facilitate their transition, first, scientists and practitioners need to consider farmers' vision of the transition, build on and respect local traditions (including inherited practices), understand their motivations, and then strengthen those practices that require more attention – using the approach of options by context (Nelson et al., 2019; Sinclair and Coe, 2019). Mixed farmers would greatly benefit from improved varieties and decision support systems, but they would also accelerate their transition by creating stronger farmers' associations and facilitating their access to extension (or digital extension) and credits. At the institutional level, target microcredits could be an option to promote the reduction of pesticides when complemented with financial literacy (Kipkogei et al., 2025). Last but not least, AE farmers also need a better linkage with the market and realise that they should not be overloaded with activities as AE practices require more labour and, in some cases, more strengthening of the farmers organisation. At the end, there can be different alternatives, but the mantra should be not do harm.

6 Conclusions

The results of this study suggest that it is imperative to consider context-specific and complex aspects for successful AE interventions. As shown in the study by Muleme et al. (2017) in Uganda, providing knowledge training can help influence perceptions and attitudes. However, that is not sufficient to change practices related, for instance, to pesticide use. Akin to our participants, Ugandan farmers' risk-aversion towards economic losses was often stronger than their knowledge of the hazards of pesticide use and their family's natural traditional methods. Similarly, the lack of contextually appropriate practices and consideration for farmers' priorities and socio-economic situation caused the failure of IPM initiatives in Cambodia (Dunn et al., 2023). Furthermore, Dunn et al. (2023) identified a phenomenon of 'pesticide lock-in' as a form of pesticide dependency that Cambodian producers had developed, whereby their risk-aversion played such a significant role in determining their behaviour that they would not reduce pesticide use despite possessing adequate knowledge of their risks as well as of potential alternative natural pest control practices. An analogous occurrence was found in smallholder farmers in Kenya, who held views that biopesticides were not as effective as chemical ones (Constantine et al., 2020).

It is also crucial to acknowledge that all farmers have practices, and we need to understand how to integrate new ones into their management. Equally crucial is to find ways to communicate our results to *non-converted* farmers (clearly shown in Figure 3) and what the limitations would be around them.

Additionally, the role of women can be central in facilitating AE practices' adoption and contributing to shifting values within households otherwise more oriented towards conventional production (Mestmacher and Braun, 2021). It is important for women to not merely play an instrumental role, but to become empowered in the process, such as the examples in our results where women had agency over their income (Borja et al., 2024; FAO, 2018; Zaremba et al., 2021).

Finally, our investigation calls attention to the importance of understanding *how* the convergence of all the factors above, together with the necessary enabling conditions for farmers, yields dissonant responses in farmers' actions in AE transition processes. These aspects will need to be further explored through approaches that combine interventions and research, where the learnings can be used to support AETs.

Overall, the persistence of chemical use can be seen as the result of loss-averse decision heuristics operating under conditions of institutional vulnerability, reinforcing the need for policies that buffer downside risk if AE adoption is to expand (Scoones, 1998; Pan et al., 2020).

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required because the participants of the study were already participants and beneficiaries of the project and involved in a process of participatory action research, where knowledge was co-created with them. They participated in the process of analysis of data and interpretation of results. Furthermore, informed consent was obtained from each participant verbally. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements. Informed consent was obtained from each participant verbally. Verbal consent helped avoid generating distrust, as requiring a written informed consent could have raised suspicions of participants' further responsibilities.

Author contributions

MO: Data curation, Investigation, Writing – original draft, Methodology, Writing – review & editing, Conceptualization, Formal Analysis, Validation. RA: Methodology, Supervision, Writing – original draft, Conceptualization, Writing – review & editing. IN: Writing – review & editing, Formal Analysis, Visualization. MZ: Conceptualization, Funding acquisition, Project administration, Writing – review & editing, Supervision. CB-Z: Writing – review & editing, Supervision, Conceptualization, Methodology.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix 1 Interviews to 30 producers, during the investigation stage

Interview with producers that sell in popular fairs

1 General data

Producer's Name: PGS: YES NO Age:

Type of Offer: 80–100% AE 50%–50% 20% AE 0%

Seasonality of the offer: All year: only certain months (which ones):

Address: Community Municipality

Organisation/Association: Formal: Informal:

Any institutional support: Which:

Date: Cel:

2 Questions (ask for consent to record or take notes)

0. Do you make a living out of agriculture or do you have other sources of income? Which ones?

1.1 Do you produce only agroecological, conventional or mixed? Why? How do you cultivate the food? (Fill out the practice table)

Cultivation practices and why, breeding of animals and how they breed them, proportion of agroecological and of conventional production, if they produce conventional as well and why (i.e. mixed production).

1.2 Why do you produce in this way (i.e. agroecological, conventional or both)? What motivates you? Is there anything that demotivates you?

In their motivations investigate especially (i) the search for economic alternatives, (ii) health (theirs or of their family), (iii) training and technical assistance, and, (iv) belonging to an association, organisation (formal or informal). Have they always produced agroecologically? When did they convert? Why did they convert? Is there anything that demotivates them? (low demand)?

If they are agroecological producers:

2.1 How do you market your production? Do they carry only theirs or someone else's too?

Who else's do they carry? Why do they carry someone else's products? Why don't they carry someone else's products? How often do they carry them? In what conditions? Are they agroecological or it does not matter? If you refuse to carry them, would something happen? In what fairs do you sell? How often do you sell in those places? In Cochabamba who does help you sell, why? What happens with your stall in the fair when you don't have any products (in Winter or in dry times) and you can't go to the fair? What happens if you have left over products the day of the fair, what do you do with them? What is your relationship with the fair leaders? (if they have voice or vote in the decisions).

2.2 Have you sometimes sold to intermediaries? Where? To whom? Why? In what conditions?

What do you feel, think about the price that you receive?

3.1 Do you have caserit@s (i.e. trusted sellers) from whom you always buy your agroecological products? What did they do to gain your trust and what do you buy frequently from them?

How do you relate to their customer? What are your strategies? How do you feel seeing that they come back to buy from you? What would happen if you stopped doing those practices? Is it important to gain the consumers' trust? Why? Why is it that some agroecological sellers do not gain consumers' trust? And why is it that some consumers do not trust any agroecological producer?

3.2 Do you differentiate your agroecological products in your sales stall? Or your sales stall as agroecological? Why yes? Why not?

Is everything you have agroecological? Or mixed? Why? Does the consumer know which ones are agroecological and which ones are not? What would happen if you started to differentiate? Why don't your neighbours differentiate? Would you like to differentiate? How and why? What do you think and feel about the price that you receive?

If they are mainly conventional or only conventional producers:

1. Did you receive training about agroecological production? What did you learn from agroecological production?

Investigate the level of theoretical and practical knowledge about agroecological production.

Were you an agroecological producer sometime and now you are not anymore? Why did you stop being an agroecological producer?

Investigate on the limitations, difficulties, demotivating factors.

Or, if you haven't been an agroecological producer, but you know about agroecological production, why didn't you start being one?

Investigate on the limitations, difficulties, demotivating factors.

2. How is your family consumption?

(Do you eat what you produce, do you produce agroecologically separately for yourself? When do you buy, look for agroecological products? Deepen how their consumption is, how they choose their food).