Geoforum 90 (2018) 183–205

Contents lists available at ScienceDirect

Geoforum

journal homepage: www.elsevier.com/locate/geoforum

Assessing regional farming system diversity using a mixed methods typology: The value of comparative agriculture tested in broadacre Australia

Myrtille Lacoste[a,*], Roger Lawes[b], Olivier Ducourtieux[c], Ken Flower[a]

[a] The University of Western Australia, School of Agriculture and Environment, The UWA Institute of Agriculture, Crawley, WA 6009, Australia
[b] CSIRO Agriculture and Food, Floreat, WA 6014, Australia
[c] AgroParisTech, University Paris-Saclay, UFR Comparative Agriculture, UMR PRODIG, 75005 Paris, France

ARTICLE INFO

Keywords:
Farming systems
Agrarian systems
Farm typology
Farmer practices
Mixed methods
Multivariate cluster analysis

ABSTRACT

Most farm and farmer typologies focus on specific aspects and use standard structural and socio-economic indicators. Regional assessments of agricultural diversity based on farming systems are rarely done, as detailed and representative information is difficult to collect. The discipline of comparative agriculture addresses these challenges but remains little known, and seldom applied to broadacre situations. This study demonstrates in Western Australia the value of its mixed methods and multi-disciplinary concepts to determine the level and nature of regional farming system heterogeneity.

The typology built comprised six farming systems based on 36 farms that represented half the farming population of a 4000 km^2 area (broadacre rainfed systems dominated by winter cereals and sheep, Mediterranean climate). The farm groups corresponding to these farming systems differed across 36 variables representing biophysical, technical, and social aspects at varied spatial and temporal scales. Results were compared with five sets of farm clusters produced through multivariate clustering procedures commonly employed to build typologies. These farm clusters differed across fewer variables than the farm groups of the comparative agriculture typology.

The analytical, methodological and conceptual tools used in comparative agriculture to solve the challenges associated with the holistic study of farming system heterogeneity are discussed. These included basing data collection and analysis on an empirical approach that assessed groups of farms rather than individuals, solving data scarcity through a range of qualitative techniques, and progressively informing the choice of typology criteria. Comparative agriculture thus provides an alternative to standard typology paradigms that deserves wider application.

1. Introduction

Farming systems research explores complex mechanisms, such as how farm enterprise mix and productivity interact with agronomic processes, labour requirements, commodity markets, climate, machinery and scheduling operations. Such explorations often require detailed information about the current status of the farm and the organisation of its resources. Regional assessments of the diversity of farming systems are also needed to determine how variable the processes investigated are. This information is necessary to identify which mechanisms should be addressed, the extent to which they can be impacted, and to whom in the farming population and where in the landscape such decisions may apply. Capturing and determining diversity is crucial to define effective pathways to impact and to measure realistic scopes. Within a region, sub-populations are likely to react differently to policies, extension, goods and services. For instance, the potential adoption of practices and technologies is relative to the characteristics of target groups (e.g. Andersson and D'Souza, 2014; Kuehne et al., 2017). Some form of classification that aggregates farms into relatively homogenous groups is required to capture the heterogeneity of farming systems. These groups can be used to define types of farming systems, which together form a typology, i.e. a tool that provides researchers and decision-makers with a simplified yet relevant representation of the diversity of situations encountered within the region (Tittonell et al., 2010; van der Ploeg et al., 2009).

Numerous typologies have been constructed for a variety of purposes (see for instance references within Emtage and Herbohn (2012) and Kuivanen et al. (2016b)). However, most typologies are based on a given range of farm or farmer characteristics and do not necessarily match farming systems, i.e. the structural and functional organisation

* Corresponding author at: The University of Western Australia, School of Agriculture and Environment M087, 35 Stirling Hwy, Crawley, WA 6009, Australia.
E-mail address: myrtille.lacoste.ag@gmail.com (M. Lacoste).

https://doi.org/10.1016/j.geoforum.2018.01.017
Received 4 January 2017; Received in revised form 31 October 2017; Accepted 24 January 2018

of the farm that underpins its production processes (Sturaro et al., 2009; van der Ploeg et al., 2009; Vanclay et al., 2006). Efforts are generally made to consider several farming aspects; however, holistic procedures that take into account complex relationships between multiple indicators across the entire farm are rare. For instance, Valbuena et al. (2008) and Blazy et al. (2009) noted that landscape attributes are rarely integrated. In addition, the few examples of farming system typologies available are limited to regions where agriculture is quite diversified (Choisis et al., 2012; Kuivanen et al., 2016b; Tittonell et al., 2005). Examples are particularly lacking in broadacre agriculture. Instead, farm typologies in these regions focus on particular aspects such as subsystems, financial performances, given practices, farmers' attitudes or perceptions (Aouadi et al., 2015; Emtage and Herbohn, 2012; Greiner et al., 2009; Kingwell et al., 2013; Sherren et al., 2011; Stott et al., 2013; Waters, 2009). Alternatively, farming populations are separated into groups based on factors such as farm size and financial attributes (ABARES, 2016; van der Ploeg et al., 2009).

The difficulty of addressing regional heterogeneity in terms of farming systems resides in deciding which variables are most relevant, and which process to follow to aggregate farms. To be valid, a typology of farming systems must be based on groups of farms that are different in terms of farming resources and productions. This includes the nature and amounts of these resources and productions, as well as their organisation and conditions of renewal. Land, labour, financial and human capital, as well as the local social relationships of production and trade, are combined into specific management strategies and productions. Each component is nuanced, with interactions spanning several temporal and spatial scales (seasonal, yearly or longer time frames at the plot, farm or regional levels). To reflect the farming system mechanisms, a range of both structural (e.g. hectares, equipment, labour units) and functional (e.g. scheduled operations, resources allocation, nutrient fluxes) variables must therefore be included when aggregating farms. Social variables may also be relevant, for instance when aspects of the family unit or farm history influence the organisation of labour, or when societal and institutional circumstances impact the access to goods and services.

As a consequence, a farming system typology implies that many agronomic, economic, environmental and social variables, all potentially of importance, must be considered. However, farm information that is representative and detailed enough to appraise the heterogeneity of farming systems is rarely available and is difficult to obtain, even in industrialised countries where agricultural census and large surveys are regularly conducted (Aouadi et al., 2015). Big data and remote sensing can generate large amounts of bio-physical information, but details about agricultural resources and practices remain scarce as collecting farm, farmer and rural information rapidly becomes costly, highly demanding in resources, and difficult to manage (Navarro et al., 2016). The issue is further made more complex by the inherent variability of agriculture that generally requires large datasets for significant relationships to be identified, and by the need to include long-term information to avoid capturing static pictures of systems that are constantly changing (Iraizoz et al., 2007).

This study used the multi-disciplinary concepts and applied mixed methods of *comparative agriculture* (Cochet, 2015) to solve these issues and determine the typology criteria that could adequately capture regional variations in terms of farming systems. This integrative discipline remains little known in English-speaking academia (Gautier and Kull, 2015; Hervieu, 2012); (Lacoste et al., 2017). Published examples applied to broadacre situations are particularly lacking.

The holistic framework of comparative agriculture emphasises the need for in-depth investigations that are grounded in field work and integrate both technical and social aspects at varied spatial and temporal scales (Aubron et al., 2016; Cochet, 2012; Mazoyer and Roudart, 2007; Moreau et al., 2012). The validity of such a typology was examined for its ability to capture and describe the heterogeneity of farming systems in a broadacre region of Western Australia. First, the effectiveness of the methods used was tested by assessing whether the groups of farms discriminated by the typology differed in terms of farming systems, i.e. across a wide range of structural and functional characteristics at both field and whole-farm scales. Second, the extrapolation potential of the typology was tested by using its results to define simple classification rules. These rules were applied to the original dataset, and the resulting farm groups compared with those of the typology. Third, the performance of the methods used was compared with that of multivariate procedures commonly employed to define farm and farmer typologies. This was done by comparing the number of variables that differed between the farm groups of the typology and between farm clusters produced statistically, i.e. by showing the extent to which each classifying procedure provided insights regarding the diversity of the farming population studied (maximum homogeneity within groups and maximum heterogeneity between groups, Emtage and Herbohn (2012); Iraizoz et al. (2007)).

These results are then discussed, showing how the methods of comparative agriculture solved issues related to the characterisation of farming diversity, and how its typologies differ from those dominating the literature on farming diversity.

2. Material and methods

2.1. Region and study area

The study area occupied approximately 4000 km^2 and was located in the Western Australian wheatbelt, one of Australia's main grain growing regions where the main productions are cereals and sheep (117°28′E, 31°23′S, Fig. 1a). Across this 20 million hectare region, about 4000 rainfed broadacre farms, most of which are several thousand hectares in size, produce ten million tons of grains. This includes a third of the country's wheat tonnage, produced with yields slightly less than 2 t/ha on average (ABARES, 2014). The location was chosen for its central position in the wheatbelt, where ongoing applied and modelled research would allow for comparisons and further use of results.

The climate is Mediterranean-type, with hot dry summers and mild wet winters. Annual rainfall is low and variable, on average 300 mm, about 65% of which occurs during the growing season between May and October (BOM, 2015). There is one winter crop per year, followed by a summer fallow. Crops are seeded in April-June and harvested in November-December. The majority of farm businesses are crop dominant in no-tillage systems (knife-points seeding). The main crops are wheat, barley, canola, lupin. Sheep mostly graze annual volunteer pastures and crop stubbles, sometimes seeded legumes pastures. Although the region is dominated by sands and low relief, soil heterogeneity is high. Further information about the study area is available in Lacoste et al. (2016).

2.2. Farming system typology: procedure, sample, data

2.2.1. Procedure

To produce a typology capturing the diversity of farming systems existing in the study area, an *agrarian diagnosis* was conducted over 12 weeks by one investigator during May-August 2014. Also called *agrarian system diagnosis-analysis* and usually conducted at relatively small regional scales, this mixed methods procedure applies the multidisciplinary concepts of comparative agriculture (Barral et al., 2012; Cochet, 2015). It consists of an iterative process during which direct observations and farmer interviews are central, data collection and analysis are largely conducted concurrently, and the information to be collected is progressively prioritised. This allows reducing the complexity of the agricultural situation using informed decisions while keeping the investigation manageable, collecting both qualitative and quantitative information that is representative and high quality. The steps of the agrarian diagnosis are summarised in Fig. 2. In this study they were conducted as follows: