

# Variability of European farming systems relying on permanent grasslands across biogeographic regions

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## Abstract

The relevance of permanent grasslands (PG) for a large share of European farms is high, and yet understudied. We used single-farm records from the FADN (Farm Accountancy Data Network) database 2017, which included 41,926 farms-with-PG to characterize PG-based farming systems. Each farm was assigned to one class in terms of: (1) main livestock species/category; (2) stocking rate on total farmland; (3) PG share; (4) biogeographic region (BGR). We carried out a Multi Correspondence Analysis (MCA) on the resulting classification, which explained 20% of the variance. The five BGR separated well in the first two MCA dimensions. Alpine farms were predominantly related to beef cattle, with relatively low stocking rates, and intermediate to high PG shares. Atlantic farms also revealed high PG shares, but were linked to higher stocking rates and 'Mixed bovine' and 'Dairy cow' farming. The dominance of farms without livestock in the Boreal BGR resulted in generally very low stocking rates and showed a limited importance of PG. Continental farms were not clearly related to one specific livestock category or a stocking rate, but consistently showed a share of 10-30% PG per farm. Finally, the Mediterranean BGR separated from the others, being dominated by sheep and goat farming.

**Keywords:** Europe, farming system, grassland management, livestock species, meadow, pasture, stocking rate

## Introduction

Farming systems (FS) are the result of environmental conditions, historic and cultural factors, policies, and management practices. Based on these regional differences, the ability of different FS to deliver ecosystem services (ES) can vary widely (Ribeiro *et al.*, 2021). Therefore, it is important to recognise which factors differentiate FS from each other, to address further actions to improve productivity and sustainability, create resilience, optimize farm profitability, and deliver ES for the society (Santos *et al.*, 2021). Permanent grasslands (PG) provide high-quality fodder and are able to deliver a variety of important ES (Roy and Potschin, 2018). A first attempt to implement a FS typology considering the role of PG within farms was provided by Hercule *et al.* (2017), but based only on grassland share within farms and animal stocking density. To overcome these limitations, we implemented a new FS typology within the H2020 project 'SUPER-G' (Developing SUSTainable PERmanent Grassland systems and policies), aiming to identify the main FS that rely on PG, with a view to assessing the extent to which different FS deliver multiple ES. Livestock species, stocking rate, PG share, and the biogeographic region (BGR) were selected as discriminating factors, and their role in differentiating European FS is discussed here.

## Materials and methods

A dataset containing single farm records was retrieved from the 2017 Farm Accountancy Data Network (FADN) and used as a representative sample of European farms. The main advantage of working with FADN data, is the A subset of records including only farms with PG was selected, which included 41,926 farms located in 1063 NUTS3 regions belonging to 28 European countries. Each farm was assigned to a class according to four descriptors (i.e. qualitative variables). The first variable was the main livestock species/category, i.e. the species or category accounting for more than 75% of livestock units (LU) on the farm, selected among: beef cattle; milking cows; mixed bovines (i.e. farms with both beef cattle and milking cows); sheep and goats; mixed ruminants (i.e. farms with bovines - either beef cattle, or milking cows, or both - and sheep or goats); mixed and others (i.e. farms with other livestock species such as horses or pigs together or not with bovines, sheep, or goats). The second variable was the stocking rate on total utilised agricultural area (UAA) of a farm, calculated as the ratio between LU of main domestic herbivores (i.e. bovines, sheep, goats, and equines) and the UAA, which resulted in four classes (<0.5; 0.5-1; 1-2; >2 LU ha<sup>-1</sup>). The third variable was the PG share of the UAA, divided into five classes (<10; 10-30; 30-50; 50-70; >70%), and the fourth variable was the BGR where the farm was located (i.e. Alpine, Atlantic, Boreal, Continental, or Mediterranean). The resulting dataset containing the four qualitative variables was used to perform a multiple correspondence analysis (MCA). The analysis was carried out in R (v. 4.0.3, R Core Team 2020), using 'FactoMineR' package (Husson *et al.*, 2016).

## Results and discussion

The FADN database proved to be effective to explore farm variability throughout Europe, due to the vast amount of available data covering all regions of EU-28. The first two dimensions of the MCA explained 12.6 and 9.1% of the total variance, respectively (Figure 1). The five BGR separated quite well in the first two MCA dimensions. More specifically, the typical FS of the Alpine BGR was mainly related to beef cattle, relatively low stocking rates, and intermediate to high PG share per farm in line with Sturaro *et al.* (2009), highlighting the extensiveness of FS. The Atlantic BGR also showed high PG shares but, compared to the Alpine BGR with higher stocking rates and more 'Dairy cow' farms as shown by Stypinski (2011), indicating more intensive FS. Farms without or with mixed livestock dominated in the Boreal BGR and were associated with very low stocking rates and a very low PG share per farm. This is likely determined on the one hand by agricultural intensification, leading to spread of temporary grasslands at the cost of PG, and on the other hand by abandonment of extensive PG (Aune *et al.*, 2018). The majority of the continental farms were mostly related to 10-30% PG share class but not clearly to a specific livestock category or stocking rate, which is probably due to the high variability of environmental and socio-economic conditions of this BGR. Finally, the Mediterranean BGR, in the upper part of the plot, clearly separated from the other BGRs, being strongly related to the presence of small ruminants on farm. Indeed, sheep and goats are the species mostly kept in the Mediterranean area (Porqueddu *et al.*, 2017), due to their ability to exploit low quality forage.

## Conclusions

The FS typology developed for this study provides a selection of factors that can be used to distinguish farm types that rely on PG according to their level of management intensity, and the delivery of associated ES. Such a typology helps understand the variability of farming systems across BGR of Europe and the role of PG in supporting each of them. The typology could also be important for grading farms according to their ability to deliver ES to the society, while promoting the development of sustainable management practices and agri-environment schemes. Future research should also consider the variability in distinct types of PG, between and within BGR, as a key factor shaping ES delivery of FS at farm level.

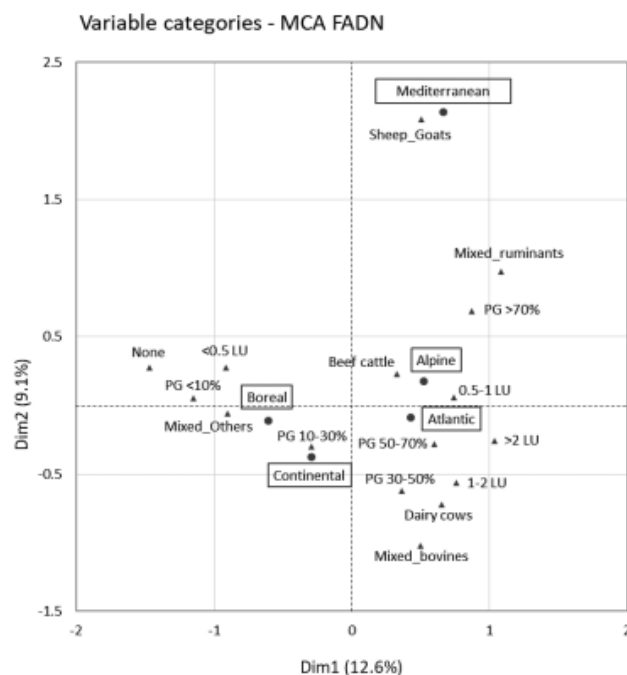


Figure 1. Relationships between variable classes in the first two MCA-dimensions performed on the FADN database. The variance explained by each dimension is reported in brackets. LU, livestock units, PG, permanent grasslands.

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