Programa de Doutoramento em Alterações Climáticas e Políticas de Desenvolvimento Sustentável (PDACPDS)

Theories and Practices of Sustainable Development (TPSD)

The CHOICE of Farming System by farmers: drivers and impacts

Group work protocol

The issues:

- What are the productive options (Farming Systems) available for farmers in the study region?

> What to produce in the farm? e.g. Either cereals, wine or milk? (specialized) or all of them (mixed)? How to produce? Using high- or low-intensity methods? Using more labour or machines? More concisely: Which are the available Farming Systems in the study region?

- Which are the biophysical and socioeconomic drivers of the choice among available Farming System options? What is constraining / pushing a farmer to choose a particular Farming System option?

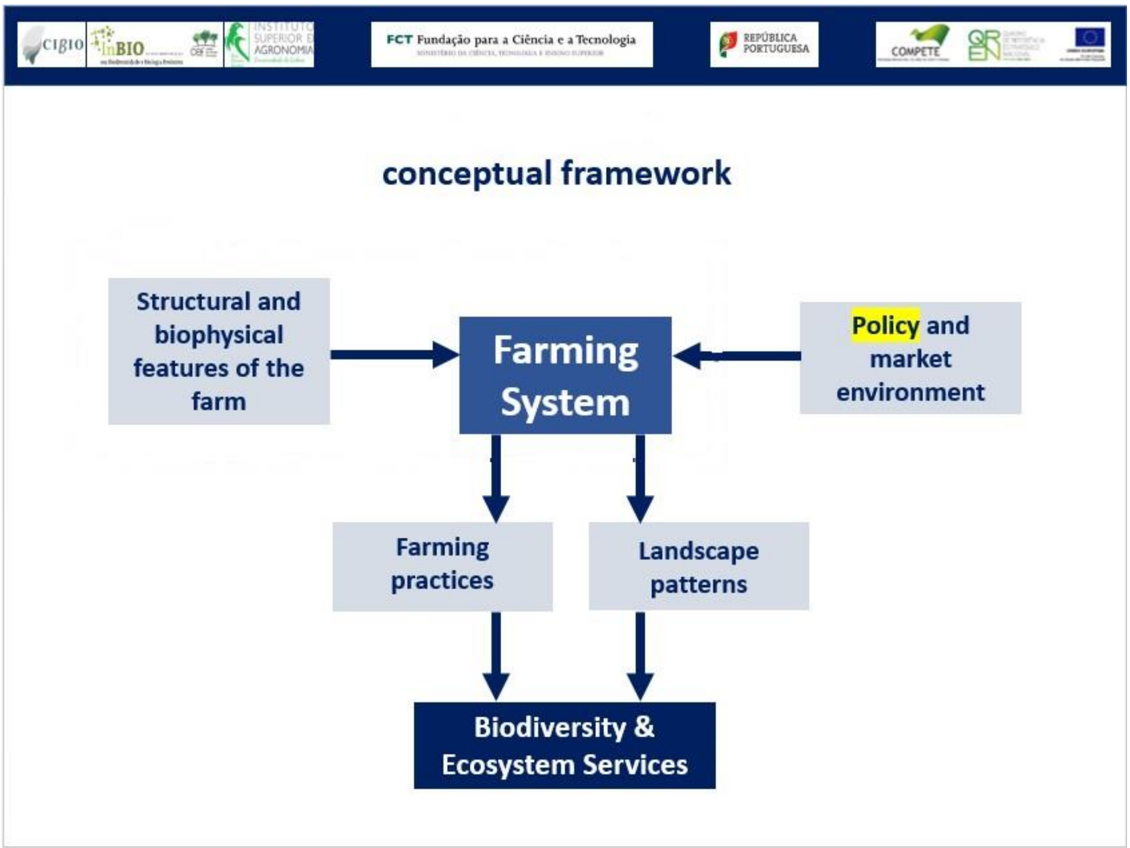
> Are small farmers pushed to produce more intensively, to take the most out of their small farm? Are farmers less integrated in the market constrained to produce a little of many things (rather than a lot of a single product) to satisfy their diverse consumption needs? In other words, are these farmers constrained to choose less specialized (or mixed) farming systems?

- Which are the impacts of Farming System choice on the landscape, biodiversity and ecosystem services?

> Are farmers choosing specialized farming systems shaping more homogeneous (less diverse) landscapes? Are farmers choosing intensive farming systems (more fertilizers, pesticides to produce more per hectare) leading to biodiversity loss?

The Farming System approach:

From policy to Biodiversity and Ecosystem Services (BES) through the choice of Farming System by farmers



A farming systems approach to linking agricultural policies with biodiversity and ecosystem services

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Many countries are reshaping their agricultural policies to better enhance biodiversity and ecosystem services (BES) in farmlands, but measuring the effectiveness of policy instruments in BES delivery is challenging. Using the European Agricultural Policy as an example, we propose the application of a farming systems (FS) approach as a cost-effective tool for linking policy design and expected BES outcomes. On the basis of available data from subsidy payment agencies, such an approach can identify groups of farms that share similar management practices as well as the associations between FS and corresponding BES potential, and improve modeled outputs of farm management responses to policies and other drivers of change. We describe how this relatively unexplored source of information can help to support applied ecological research and relevant policy, and call for these data to be made available across Europe and elsewhere.

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Farming System – the concept

The Farming System approach is a way to integrate, in a synthetic and systematic way, many choices made by farmers about the way they manage their land, which are relevant to understand environmental and other problems, such as food security.

A farming system is a particular way of:

- combining certain amounts of different inputs, e.g. land of a specific type, human labour, machines, fertilizers,
- to produce a specific mix of outputs, e.g. milk, apples …
- that is <u>common to a set of farms</u> (Fig. 2).

(Reboul, 1976, with adaptations)

The farming system it is the same (or similar) “recipe” used by these farmers, including (1) the ingredients, (2) their proportions, and (3) the cooking protocol (sequence of practices) used to get (4) the final combination of dishes.

The fact the farming system is common to a set of farms means that <u>farms can be classified by farming system</u> (Fig. 2).

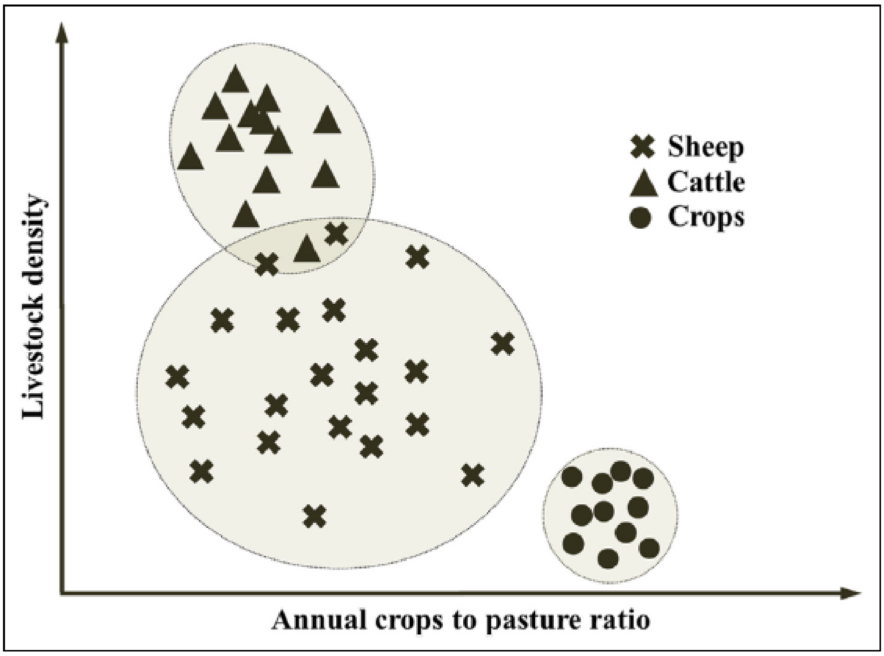

Figure 2. Conceptual representation of an FS. Each symbol corresponds to a farm that lies along two axes representing livestock density (livestock units per unit grazing area; y axis) and a pasture-to-cropland gradient, expressed as a ratio (area of cropland to area of pasture; x axis). Farms are clustered into three types of FS, consisting of crops, sheep, and cattle. Although some variability in management occurs among farms within a given FS along these axes, farms that adopted a particular FS will likely exhibit much greater similarity to one another than they will to farms that adopted a different FS.

Farming System descriptors versus drivers

Variables defining or describing the Farming System, that is Farming System **descriptors** are, by definition, dependent on (/endogenous to) the farmer's productive choices.

A variable such as rainfall is, at the farm scale, exogenous to (independent from) such choices, and thus it is not a farming system descriptor. However, rainfall is a very relevant factor affecting the choice of Farming System by a farmer: farmers typically choose different Farming Systems in dry (low rainfall) and wet (high rainfall) areas. Variables that affect farming system choice but are not affected by this choice (exogenous variables) are called **drivers** of farming system choice. Farm size is also often a driver of choice, not a Farming System descriptor. Why?

Usually, what describes a farming system is the **proportions** or **quotients,** such as:

- % of pastures in total Utilized Agricultural Area in the farm;
- ton of maize produced per hectare;
- amount of water used per hectare of irrigated land;
- % of milk in the Total Revenue of the farm;

- number of heads of livestock per hectare.

… **not** the physical or economic **dimension** of the farm, measured by indicators such as:

- farm size (in hectares);
- total yearly revenue (in Euros/year);
- total livestock in the farm (in Standard Livestock Units).

This is because the same "recipe" (that is the same proportions of ingredients, the same farming system!) can be used to cook cakes of different sizes. A farm with 100 hectares and 400 dairy cows, and another with 10 hectares and 40 dairy cows, with same technology, may be practicing the same farming system.

Different dimensions of Farming System description

A farming system can be described according to different **dimensions**, which should be kept separate. Farming system **descriptors** should be grouped according to these dimensions. Usually, these dimensions can be organized in two choices:

A) What to produce?

- Land use – proportion of the areas of the main crops, and other land uses (e.g. fallows);
- Proportion of the different livestock species in total Livestock units in the farm;
- Specialization level - according to the % of the most relevant output in Total Revenue, farms (and Farming Systems) are either specialized or mixed;
- Specialization pattern, i.e. the main outputs and their proportions;

B) How to produce?

- Output intensity, or productivity of land, in ton of output per hectare.year or Euros of Farm Gross Revenue per hectare.year;
- Input-intensity, in cubic meters of water per hectare, Kg of fertilizer per hectare.year or overall Intermediate Consumption in Euros per hectare.year (considering only inputs that are used to raise the productivity of land);
- Mechanization level, Utilized Agricultural Area per worker, Capital to Labour ratio, or other general indicators of techniques used to replace human work by machines and motors.

Impacts of Farming System choice, and impact variables

The choice of one (instead of other) Farming System often has an impact on Biodiversity and Ecosystem Services (BES). Thus, Farming Systems can be compared as regards their impact on BES, by comparing, for example, the average of a particular **impact variable** (such as species richness, landscape diversity or wildfire frequency) across Farming Systems. One way to carry out this comparison is building Confidence Intervals for this average impact variable across Farming System (Fig. 5).

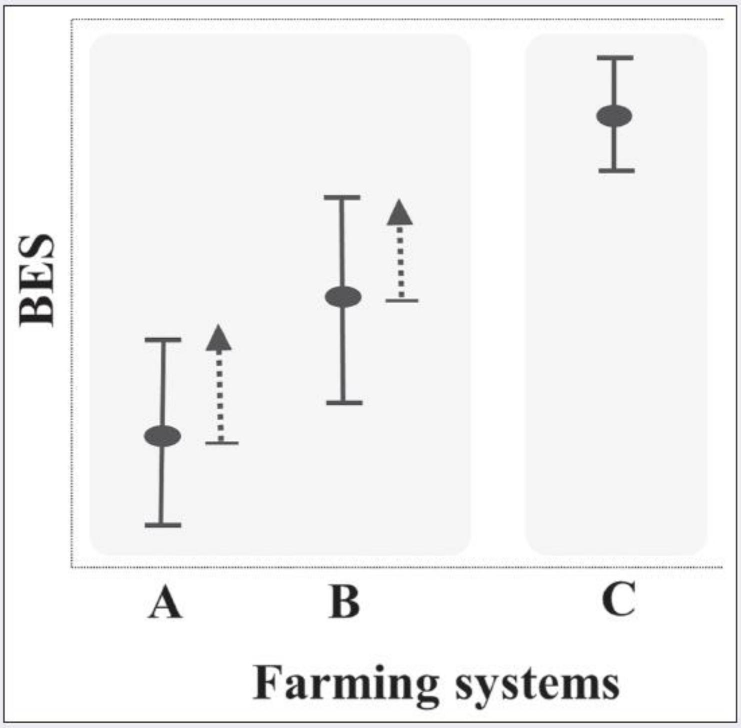

Figure 5. Potential delivery of BES (means and confidence intervals) across three FS types (A, B, and C). FS type C is clearly better than types A and B, and can be used for an FS approach. However, little difference exists between FS types A and B, and therefore locally targeted approaches such as agri-environment or results-based systems would likely be more effective in enhancing BES potential in these cases (dotted arrows).

Group work – step by step

Step 0. Previous steps

Until the 12th March - six groups are expected to form and choose among the following six themes:

Group 1. North Region Drivers

Group 2. Centre Region Drivers

Group 3. South Region Drivers

Group 4. North Region Impacts

Group 5. Centre Region Impacts

Group 6. South Region Impacts

Step 1. Identifying and describing the Farming Systems in the study area (<u>for all groups</u>, i.e. IMPACT and DRIVER groups)

1. Each group deletes all lines in the database that include parishes that do not belong to their study region, and keep only the lines that correspond to their study region;
2. Each group classifies each of the variables in the database in one the following three categories: (a) Farming System descriptors, (b) drivers of Farming System choice, and (c) impacts of Farming System choice;
3. Each group then re-organizes the database by changing the position of the several columns (variables) to put all descriptors first (left), drivers next (middle) and impact variables next (right).
4. The variables classified as Farming System descriptors are then grouped according to the abovementioned dimensions of farming system description;
5. The columns in the database with descriptors are then re-organized by dimensions, in a way similar to 2.
6. The variables classified as drivers are grouped, according to their nature, in two classes: biophysical and socioeconomic drivers.
7. The columns in the database with drivers are then re-organized by dimensions, in a way similar to 2.
8. The group then selects N descriptor variables (<u>the defining variables</u>) to carry out a Principal Component Analysis (PCA) of the data. PCA aims at reducing the redundancy (correlation) between these variables. The PCA eliminates redundancy by reducing the number of variables N to a much smaller number of PCs (Principal Components) that are not, by definition, correlated with each other.
   - the selected defining variables to be include in the PCA should represent all of the abovementioned dimensions of Farming System description;
   - in the PCA, the group should use the eigenvalue method to select the relevant PCs and ask the SPSS to save, in the database, the coordinates of each observation (parish) in the selected PCs;
   - the group should save and interpret: (a) the SPSS table with the proportion of the initial variance in the data that is captured by each PC, and cumulatively in all selected PCs; and (b) the table with the correlations between the N initial (defining) variables and the M PCs that were selected by the eigenvalue method;
9. a hierarchical cluster analysis should then be run on the saved coordinates of each observation (parish) in the selected PCs, using the squared Euclidean distance as distance measure, and the Ward method as clustering method; all cluster solutions between 4 and 15 clusters should be saved by the SPSS in the database; the SPSS should be instructed to provide the dendrogram resulting from the cluster analysis;
   - the best solution among the 4 to 15-cluster solutions will be selected by: (a) observing the dendrogram; (b) comparing the averages of the N defining

variables across clusters for each of these solutions; (c) checking whether these averages are statistically different (ANOVA and Confidence Intervals); (d) avoiding clusters that are too small (which causes non-statistically different averages); and (e) selecting the solution with the smallest possible number of clusters that still represents well the diversity of Farming Systems in the study region;

- to assist/validate this selection of the best cluster solution, the group will map the several cluster solutions, using the q-GIS software; to map each cluster solution, the group will use DICOFRE as the linkage variable to associate each line (parish) in the database with the shape of the same parish in the digital Administrative Map of Portugal (CAOP 2019 shape file); these cluster maps are to be compared with the geography of the study region (mountains, valleys, drier and rainier areas, urban network) as a further test that helps selecting and validating the best cluster solution;
- characterize the clusters included in this best solution by comparing the averages of all descriptor variables (that is all defining variables + all remaining descriptors, or characterizing variables); the p-value of the one-way ANOVA and the Squared ETA should also be computed for each of these variables;
- interpret clusters in the best cluster solution by calling each of them a name that reflects the dimensions of Farming System description that best separate the clusters (highest squared ETAs);
- the group then maps the best cluster solution using q-GIS.

Step 2. Analysing the drivers of Farming System choice (only for DRIVERS groups, that is: Groups 1-3)

- mapping of biophysical and socioeconomic drivers in the study area, using the q-GIS software;
- comparing the averages of biophysical and socioeconomic drivers across the clusters established in Step 1, by using compare means, one-way ANOVA, Squared ETA and 90% Confidence Intervals in SPSS;
- interpreting the results by discussing how each driver constrains/pushes farmers in different areas within the study region to choose different farming systems.

Step 2. Analysing the impacts of Farming System choice (only for IMPACT groups, that is: Groups 1-3)

- mapping of impact variables in the study area, using the q-GIS software;
- comparing the averages of impact variables across the clusters established in Step 1, by using compare means, one-way ANOVA, Squared ETA and 90% Confidence Intervals in SPSS;
- interpreting the results by discussing how impacts vary across farming systems.

Step 3. Individual report by each student

- based on a small literature review (2-3 scientific articles), each student raises 2-3 questions/hypotheses (examples of types of questions in page 1 of this document – The issues) that can be discussed/tested using some results of the group work;
- the student selects the results of the group work that are relevant to discuss/test the raised questions/hypotheses;
- the student discussed the raised questions/hypotheses based on the selected results.

Group work – calendar

9 March – Introduction to the group work (lecture)

12 March – All groups are formed and their themes are selected

15 March – Support to group work analyses (lecture)

11 April – Groups present the results of Step 1

17 May – Practical session to support the applied work of groups

24 May - Groups present the results of Step 1

7 June – Each student delivers the individual report

IMPORTANT NOTE: At any time, groups that require support to continue the work are invited to book a work session by Zoom with Profs to receive the required guidance/support.