Exploring the effects of climate change on farming system choice: a farm-level space-for-time approach

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Table S1. The farming systems of Alentejo, Portugal, in 2017 (adapted from [16]). Figures in brackets describe the livestock density, in livestock units per hectare of total agricultural area. Colours provide a legend for Figure 2. For a detailed description of farming systems see reference [16] in the manuscript

■	Cattle grazing - CO: a low intensive agroforestry system, where farmland is mostly composed of permanent pastures under the canopy of scattered trees, mostly cork oak (CO), grazed by low-density cattle herds (0.78)
■	Cattle grazing - HO: similar to the previous FS but with holm oak (HO) replacing cork oak and slightly lower livestock density (0.68)
■	Cattle grazing – forages: a low-intensity system with farmland mostly composed by pastures, and rainfed forages and cereals. Higher livestock density, mostly cattle (0.97)
■	Grazing goats: a low intensive agroforestry system, dominated by permanent pastures under the canopy of cork and holm oaks (1.04 [1])
■	Mixed Cattle and sheep - Irrigated forages: mostly composed by irrigated forages, and rainfed permanent pastures and forages. Livestock includes both cattle and sheep (0.62)
■	Sheep grazing - CO: similar to Cattle grazing - CO but with livestock mostly composed by sheep instead of cattle (0.25)
■	Sheep grazing - HO: similar to Cattle grazing - HO but with livestock mostly composed by sheep instead of cattle (0.39)
■	Sheep grazing - pastures: low intensive system dominated by rainfed permanent pastures grazed by sheep (1.00), with few or no trees
■	Sheep grazing - pastures and forages: mostly composed by permanent pastures (no trees), but including olive groves, and rainfed cereals and forages. Livestock dominated by sheep but may include some goats (0.71)
■	Sheep grazing - forages: mostly composed by forages, but also including permanent pastures and olive groves. Livestock dominated by grazing sheep, but possibly including goats (0.38)
■	Rainfed olive groves with sheep: olive groves dominate, with some pastures grazed by sheep (1.21)
■	Rainfed olive groves: a permanent crop system largely dominated by rainfed olive groves. No livestock (n.e. [2])
■	Irrigated olive groves: a permanent and intensive crop system, massively occupied by olive groves irrigated by public irrigation systems (n.e.)
■	Vineyards: a permanent and intensive crop system dominated by vineyards but also including rainfed olive groves, pastures, and fallows (n.e.)
■	Fruit trees: a permanent and intensive crop system composed mostly by fruit trees, but also with pastures under cork and holm oaks (n.e.)
■	Stone pine: a permanent and intensive crop system massively occupied by Stone pines, but with relevant pasture area under cork and holm oaks (n.e.)

Rice: an annual and intensive monoculture system, often depending on public irrigation systems (n.e.)

Irrigated cereals and horticultural crops: an annual and very intensive crop system, composed by cereals, horticultural, and industrial horticulture irrigated by public irrigation systems (n.e.)

Rainfed cereals and oilseeds: an annual and extensive crop system, composed by rainfed cereals and irrigated oilseeds (n.e.)

Rainfed cereals: an annual and extensive crop system, including autumn-winter crops, fallows, pastures and rainfed olive groves (n.e.)

Pastures (no livestock): a very extensive system dominated by pastures, occasionally including also small areas of rainfed olive groves, but without any livestock declared (n.e.)

Fallows: extensive system represented by small farms that were under fallow in 2017 (n.e.)

[1] The livestock density in this FS is likely overestimated because goats often graze outside the farm's area
[2] The livestock density in this and subsequent FS is virtually zero, so it is marked "n.e." (non-existent)

Transition matrices

The next pages present transition matrices for areal changes of farming systems from 2017 to 2081-2100 in three climate change scenarios in the Alentejo region, Portugal:

- Low emission scenario (SSP 1-2.6)
- Moderate emission scenario (SSP 3-7.0)
- High emission scenario (SSP 5-8.5)

Values are presented in relative terms (proportions).

Values below 0.01 are omitted.

Low emission scenario (SSP 1-2.6)

From \ To	Cattle grazing - forages	Cattle grazing - HO	Cattle grazing - CO	Fallows	Fruit trees	Grazing goats	Irrigated cereals and horticultural crops	Irrigated olive groves	Mixed Cattle and sheep - Irrigated forages	Pastures without livestock	Rainfed cereals	Rainfed cereals and oilseeds	Rainfed olive groves	Rainfed olive groves with sheep	Rice	Sheep grazing - forages	Sheep grazing - pastures	Sheep grazing - pastures and forages	Sheep grazing - HO	Sheep grazing - CO	Stone pine	Vineyards
Cattle grazing - forages	0.84	0.15																				
Cattle grazing - HO		0.98																				
Cattle grazing - CO	0.01	0.31	0.66																			
Fallows	0.04	0.07		0.71				0.03			0.02	0.01							0.06		0.03	
Fruit trees					0.83	0.01							0.02				0.02		0.02	0.02	0.01	
Grazing goats		0.15	0.02			0.64											0.02		0.12	0.03	0.02	
Irrigated cereals and horticultural crops	0.02		0.01				0.84	0.05	0.01			0.03										0.01
Irrigated olive groves	0.02	0.04						0.89				0.02										
Mixed Cattle and sheep - Irrigated forages		0.04					0.04	0.03	0.86													
Pastures without livestock	0.07	0.14	0.02	0.02	0.01	0.01		0.07		0.22	0.04	0.03	0.01	0.03		0.06	0.06	0.01	0.15	0.02		
Rainfed cereals	0.05	0.09		0.01				0.05			0.66	0.04	0.01			0.03			0.03			
Rainfed cereals and oilseeds							0.03	0.05			0.02	0.90										
Rainfed olive groves	0.02			0.01				0.08			0.07		0.67	0.03		0.02		0.01	0.04			0.01
Rainfed olive groves with sheep	0.02	0.02						0.03			0.04	0.03	0.06	0.69				0.01	0.05			0.01
Rice			0.03												0.96							
Sheep grazing - forages	0.05	0.07	0.06					0.05			0.03	0.02		0.01		0.61			0.05			
Sheep grazing - pastures	0.02	0.31	0.03			0.02		0.02			0.02			0.03			0.39	0.01	0.09	0.01	0.01	
Sheep grazing - pastures and forages	0.07	0.29						0.03			0.02	0.02						0.48	0.04			
Sheep grazing - HO		0.35																	0.61			
Sheep grazing - CO		0.09	0.35			0.02											0.01		0.08	0.42		
Stone pine		0.09	0.07																		0.81	
Vineyards	0.03	0.11	0.01				0.02	0.09	0.01		0.07	0.03	0.01	0.02					0.02			0.52

Moderate emission scenario (SSP 3-7.0)

From \ To	Cattle grazing - forages	Cattle grazing - HO	Cattle grazing - CO	Fallows	Fruit trees	Grazing goats	Irrigated cereals and horticultural crops	Irrigated olive groves	Mixed Cattle and sheep - Irrigated forages	Pastures without livestock	Rainfed cereals	Rainfed cereals and oilseeds	Rainfed olive groves	Rainfed olive groves with sheep	Rice	Sheep grazing - forages	Sheep grazing - pastures	Sheep grazing - pastures and forages	Sheep grazing - HO	Sheep grazing - CO	Stone pine	Vineyards
Cattle grazing - forages	0.80	0.16						0.02														
Cattle grazing - HO	0.02	0.97																				
Cattle grazing - CO	0.05	0.62	0.30																			
Fallows	0.06	0.07		0.64				0.07			0.02		0.01						0.07		0.03	
Fruit trees	0.02	0.05			0.62	0.05		0.05	0.02				0.01	0.03				0.02	0.03	0.02		0.04
Grazing goats	0.01	0.19	0.01			0.61												0.01	0.11			0.04
Irrigated cereals and horticultural crops	0.04		0.03				0.76	0.09	0.01			0.02										0.01
Irrigated olive groves	0.04	0.04						0.91														
Mixed Cattle and sheep - Irrigated forages	0.07	0.10	0.04					0.05	0.70													
Pastures without livestock	0.04	0.18		0.05				0.17		0.13	0.06	0.02	0.03	0.03		0.02	0.04		0.19			0.01
Rainfed cereals	0.06	0.08		0.02				0.16			0.58		0.02				0.01		0.04			
Rainfed cereals and oilseeds								0.16			0.02	0.80										
Rainfed olive groves	0.02			0.01				0.20			0.08		0.59	0.01					0.06			
Rainfed olive groves with sheep	0.05	0.02		0.02		0.01		0.09			0.09		0.11	0.49				0.01	0.09			
Rice	0.08					0.01		0.02							0.87							
Sheep grazing - forages	0.07	0.17		0.02				0.11			0.05	0.03	0.02	0.01		0.40			0.08			
Sheep grazing - pastures	0.05	0.35	0.01	0.01		0.03		0.03			0.02			0.03			0.27		0.15		0.01	
Sheep grazing - pastures and forages	0.11	0.29						0.09			0.05	0.02						0.35	0.05			
Sheep grazing - HO	0.02	0.42						0.01											0.54			
Sheep grazing - CO	0.01	0.40	0.21			0.05													0.20	0.10		
Stone pine		0.19	0.12																0.02		0.64	
Vineyards	0.06	0.10		0.01		0.01	0.01	0.23	0.01		0.07		0.03	0.02					0.03			0.37

High emission scenario (SSP 5-8.5)

From \ To	Cattle grazing - forages	Cattle grazing - HO	Cattle grazing - CO	Fallows	Fruit trees	Grazing goats	Irrigated cereals and horticultural crops	Irrigated olive groves	Mixed Cattle and sheep - Irrigated forages	Pastures without livestock	Rainfed cereals	Rainfed cereals and oilseeds	Rainfed olive groves	Rainfed olive groves with sheep	Rice	Sheep grazing - forages	Sheep grazing - pastures	Sheep grazing - pastures and forages	Sheep grazing - HO	Sheep grazing - CO	Stone pine	Vineyards
Cattle grazing - forages	0.80	0.16						0.02														
Cattle grazing - HO	0.03	0.96																				
Cattle grazing - CO	0.06	0.69	0.23																			
Fallows	0.06	0.07		0.61				0.08			0.03	0.01	0.01						0.08		0.03	
Fruit trees	0.02	0.07		0.02	0.58	0.05		0.06	0.02		0.01		0.01	0.03				0.02	0.04	0.01	0.03	
Grazing goats	0.01	0.22				0.58											0.01		0.12		0.04	
Irrigated cereals and horticultural crops	0.04		0.03				0.76	0.09	0.01		0.01	0.03										
Irrigated olive groves	0.04	0.04						0.90														
Mixed Cattle and sheep - Irrigated forages	0.08	0.11	0.04				0.02	0.07	0.65		0.01											
Pastures without livestock	0.04	0.18		0.05		0.01		0.17		0.13	0.06	0.01	0.04	0.03		0.01	0.03		0.20			0.01
Rainfed cereals	0.06	0.08		0.02				0.17			0.57		0.02				0.01		0.04			
Rainfed cereals and oilseeds	0.01							0.17			0.02	0.79										
Rainfed olive groves	0.02			0.02				0.19			0.08		0.59	0.01					0.07			
Rainfed olive groves with sheep	0.05	0.02		0.03		0.01		0.10			0.09		0.11	0.46				0.01	0.11			
Rice	0.09						0.02	0.02							0.85							
Sheep grazing - forages	0.07	0.18		0.02				0.13			0.07	0.03	0.03	0.01		0.34			0.08			
Sheep grazing - pastures	0.05	0.36		0.02		0.03		0.03			0.03		0.02				0.24		0.17		0.01	
Sheep grazing - pastures and forages	0.12	0.29						0.09			0.05		0.01					0.34	0.06			
Sheep grazing - HO	0.02	0.41						0.02											0.55			
Sheep grazing - CO	0.01	0.55	0.11			0.05													0.17	0.06		
Stone pine		0.22	0.10																0.02		0.63	
Vineyards	0.08	0.09		0.01			0.02	0.27	0.01		0.08		0.04	0.02					0.04			0.32