***Table 1****. Summary of management strategies used to adapt to climate and resource conditions*

|  |  |  |  |
| --- | --- | --- | --- |
| Management strategy | | | Definition |
| Resource | Spatial resource use | Free grazing | Livestock graze freely throughout the entire pasture. |
| Rotational | The pasture is divided into four paddocks. Livestock move from one paddock to another according to different strategies:  **1)** **end of the season**  **2)** **stocking rate of the paddock**  **3) body condition of livestock.** |
| Livestock | Stocking rate | Ordinary sales | In the fall, the regular livestock sale takes place. |
| Extraordinary sales | When the effects of a drought are severe, the “unwanted sale” of some cows (i.e., a sale that would not be made under other circumstances) takes place. |
| Breeding | Uncontrolled | Breeding takes place at any time of the year. |
| Controlled | Breeding takes place in summer. |
| Weaning | Natural | Natural weaning takes place at the age of 8 months. |
| Early | Weaning occurs between 1 and 7 months of age, depending on the mother's condition. |
| Feed supplementation | No | Livestock completely dependent on naturally growing pasture. |
| Yes | The livestock system supplements feed for animals below their minimum weight. |

**THREE DIFFERENT LIVESTOCK SYSTEMS**

*NOTA: Ahora mismo los únicos costes que hay en el modelo son los derivados del feed supplementation. En un año normal, a priori, el ganadero siempre tendrá un balance positivo, lo que hace que a largo plazo el ganadero termine ahorrando muchísimo dinero.*

*Por curiosidad, he decidido añadir al modelo una variable que sean* ***“otros costes”,*** *que se trata de un coste mensual para simular otros gastos sin definir del sistema ganadero (como el mantenimiento de instalaciones, gasolina, salarios, veterinario, etc.) y/o los gastos familiares del ganadero (el ganadero debe mantener a su familia con lo que gana con el sistema ganadero).* ***Por defecto he puesto que esta variable tenga un valor de 0****, por ser una variable que aún tenemos que comentar y demás, pero la dejo ahí de momento por si en el futuro queremos experimentar con ella, o lo mismo decidimos sacarla del modelo.*

**TRADITIONAL-ORIENTED** livestock farming prioritizes the preservation of traditional practices and cultural values. It involves raising livestock on open pastures, using the natural resources of the territory to support livestock production, with little or no use of external inputs. There is little attention to the improvement of cattle breeding, feed quality or herd management practices. This type of farming is often associated with low-input systems that emphasize self-sufficiency and low costs, and is practiced by small-scale farmers and communities who rely on livestock as a source of income and food.

**How ordinary sales works**: Since this farming approach does not actively manage the herd, the maximum number of animals is determined by the natural limits of the system (i.e., the availability of natural resources), not by the farmer's workload capacity. This means that apart from the normal sale of animals during the selling season, which removes animals from the system, the main factor regulating the livestock population is natural mortality due to old age and resource scarcity. On the first day of fall, they sell only all the male weaned calves and steers with the lowest OR highest live weight (with the exception of the breeding males).

**How breeding works:** breeding males and cows are constantly mixed, resulting in births throughout the year. MENCIONAR AQUI EL SLIDER ***bull:cow-ratio*** QUE DETERMINA EL NUMERO DE TOROS POR HEMBRA

**How weaning works:** calves wean naturally after eight months of age or if the mother dies prematurely.

**How rotational grazing works:** when rotational grazing is in effect, the animals move from one paddock to another at the end of the season.

**MARKET-ORIENTED** farming is a more commercial form of livestock production that is focused on profit maximization through efficient production methods, such as controlled breeding and sell of old livestock to improve the quality of the herd and the use of feed supplements to increase the number and weight of animals. In some cases, there are also practices such as rotational grazing based on animal body condition. In times of drought, a certain number of animals not intended for sale are sold off in order to maximize the profit and to purchase feed to maintain the rest of the herd.

**How ordinary sales works**: In this system, livestock is actively managed to increase production, so the maximum number of animals is limited by the farmer's workload capacity. ~~On the first day of fall, all weaned male calves and steers with the lowest OR highest live weight (except breeding males) and old cows are sold.~~

~~If after this sale the number of animals is still above workload capacity, the farmer will sell heifers and cows with the lowest OR highest live weight until the system reaches a herd size just below the farmer's workload capacity or until the system reaches a minimum number of animals set by the farmer (i.e., a minimum number of animals to prevent the system from collapsing).~~

Ahora, en el ordinary sales del market farmer, tienen lugar los siguientes procedimientos (en el siguiente orden):

1. Se venden machos: solo si en el sistema hay más de 1 bull:
   1. se venden (en función de MAYOR/MENOR peso) todos los weaned-calf-males y steers menos los weaned-calf-males que han sido seleccionados para convertirse en Bulls.
   2. Si el número de Bulls en el sistema es mayor que el ratio bull:cow, se venden X Bulls hasta conseguir el bull:cow ratio deseado
2. Se venden old cows: solo se venden old cows cuando hay vacas de reposición (heifers). Si esto ocurre, el numero de old cows que se vende coincide con el numero de heifers que hay en el sistema en ese momento, garantizando la reposición exacta.
3. Se venden old Bulls: solo si en el sistema hay más de 1 bull, se venden old Bulls.
4. Venta de hembras de no reposición: se venden las vacas adultas, heifers y weaned-calf-females sobrantes. El número de hembras que se venden viene determinado por el slider “keep-MAX-n-breeding-cows”: si el número de hembras en el sistema excede el valor de este slider, la diferencia es el número de hembras sobrantes, que son las que se seleccionan (en función de MAYOR/MENOR peso) para su venta.

**How breeding works:** breeding males and cows are put together during the summer to concentrate the birth of animals in spring, which is the season with greatest availability of resources.

MENCIONAR AQUI EL SLIDER ***bull:cow-ratio*** QUE DETERMINA EL NUMERO DE TOROS POR HEMBRA

**How weaning works:** calves naturally wean after reaching eight months of age. However, they may also wean earlier if the mother dies prematurely or if the mother's body condition falls below a certain threshold.

**How extraordinary sales works:** if at any moment of the year the average live weight of the herd is lower than the minimum live weight desired by the farmer, the farmer considers that the production of the system is at risk, triggering the sale of a certain number of animals until the average live weight of the herd returns to normal levels (i.e., is above the minimum live weight desired by the farmer) or until the system reaches the minimum herd size set by the farmer. Animals with the lowest OR highest live weight are sold following the next order: 1) male calves and steers, 2) old cows, 3) weaned-female-calves, heifers and cows. In other words, if all males have been sold and the live weight of the herd is still below the threshold or the number of animals is still above the minimum herd size, the farmer will start selling old cows until the average live weight of the herd is above the threshold or the system reaches the minimum number of animals. If these criteria are not met even after selling all old cows, the farmer starts selling female animals until one of these two criteria is met.

The purpose of this extraordinary sale is to decrease the number of animals within the system that compete for resources and to generate funds to purchase feed supplements for sustaining the remaining animals during the drought period.

**How feed supplementation works:** this system prioritizes meat production over the preservation of grasslands and animal welfare. As a result, market-oriented farmers aim to produce, maintain and sell the maximum number of animals possible during ordinary sales to maximize profits. Typically, achieving a high number of animals or meat production to maximize profits cannot be accomplished solely with the natural resources of the system. Therefore, feed supplementation is necessary to artificially increase the carrying capacity of the livestock system in order to support a larger number of animals.

In this system, the farmer purchases feed when the live weight of an animal is below a minimum live weight set by the farmer. This threshold is different for each age group. The amount of feed the farmer needs to give an animal in order for that animal to gain one kilogram of weight is determined by the Feed Conversion Ratio (FCR).

**How rotational grazing works:** during rotational grazing, livestock are moved from one paddock to another when the average live weight of the animals falls below a certain threshold. Once the animals have been moved to the new paddock, it is necessary to wait several days to see the effect of the new paddock on the live weight of the animals before the farmer considers moving the animals again if they are still below the threshold. This is because the animals need several days to acclimate to the new paddock conditions.

**ENVIRONMENTAL-ORIENTED** farming prioritizes conservation of natural resources and livestock welfare over profit maximization. This type of ranching often includes practices such as rotational grazing based on the state of the resource, which allows for better management of grazing pressure and promotes healthy soils and vegetation. Control breeding is used to synchronize the birth of animals with the season of the year with the greatest availability of resources. Exceptional sales ~~during a drought~~, such as the sale of old livestock and animals not intended for sale, only take place when the state of the resource is at risk, with the intention of maintaining the welfare of the animals and the conservation of the grasslands. Environmentally oriented livestock production often results in lower yields, with a lower stocking density ~~and a slower rate of growth of the cattle~~. This can result in higher production costs, but has the potential to create more resilient and sustainable systems in the long term.

**How ordinary sales works**: This farming approach actively manages livestock to ensure animal welfare and grassland conservation, so the maximum number of animals is determined firstly by the farmer's workload capacity and secondly by the amount of resources in the system. During the ordinary sales, **they follow the same strategy as the market-oriented farmer**: they sell all male weaned calves and steers with the lowest OR highest live weight (except breeding males), old cows and bulls and a certain number of non-replacement females with the lowest OR highest live weight until the system reaches a herd size just below the farmer’s workload capacity or until the system reaches a minimum number of animals set by the farmer (i.e., a minimum number of animals to prevent the system from collapsing)

**How breeding works:** breeding males and cows are put together during the summer to concentrate the birth of animals in spring, which is the season with greatest availability of resources.

MENCIONAR AQUI EL SLIDER ***bull:cow-ratio*** QUE DETERMINA EL NUMERO DE TOROS POR HEMBRA

**How weaning works:** calves wean naturally after eight months of age or if the mother dies prematurely.

**How extraordinary sales works:** ~~if at any moment of the year the stocking rate of the system is greater than the stocking rate desired by the farmer, the farmer considers that animal welfare and resource levels are at risk, triggering the sale of a certain number of animals until the system reaches a herd size just below the desired stocking rate set by the farmer or until the system reaches a minimum number of animals set by the farmer. Animals with the lowest OR highest live weight are sold following the next order: 1) male calves and steers, 2) old cows, 3) heifers and cows. In other words, if all males have been sold and the number of animals is still above workload capacity, the farmer will start selling old cows until the system reaches a herd size just below the desired stocking rate or until the system reaches a minimum number of animals. If the number is still above this threshold, the farmer will sell heifers and cows until the desired stocking rate or minimum number of animals is reached.~~

At the start of each season, and taking into consideration the climatic conditions of the system at that moment, the estimated daily dry matter consumption of 1 AU and the % of dry matter that will be available for cattle, the farmer estimates the carrying capacity of the system (measured in Animal Units Month, AUMs). If at the start of each season the number of animals is greater than the estimated carrying capacity of the system, the farmer considers that the environment and the resource levels are at risk, triggering the sale of a certain number of animals until the system reaches a herd size just below the desired carrying capacity or until the system reaches a minimum number of animals set by the farmer. Animals with the lowest OR highest live weight are sold following the next order: 1) male calves and steers, 2) old cows, 3) weaned-female-calves, heifers and cows. In other words, if all males have been sold and the number of animals is still above the carrying capacity, the farmer will start selling old cows until the system reaches a herd size just below the carrying capacity or until the system reaches a minimum number of animals. If the number is still above this threshold, the farmer will sell female animals until one of these two criteria is met.

The purpose of this extraordinary sale is to decrease the number of animals within the system that compete for resources and to generate funds to purchase feed supplements for sustaining the remaining animals during the drought period.

**How feed supplementation works:** ~~when the system meets or falls below the minimum herd size desired by the farmer,~~ the farmer purchases feed when the live weight of an animal is below a minimum live weight set by the farmer. This threshold is different for each age group. The amount of feed the farmer needs to give an animal in order for that animal to gain one kilogram of weight is determined by the Feed Conversion Ratio (FCR).

**How rotational grazing works:** ~~when rotational grazing is in effect, livestock move from one paddock to another based on the SR of the paddock. Once the animals have been moved to the new paddock, it is necessary to wait several days to see the effect of the new paddock on the stocking rate before the farmer considers moving the animals again if they are still below the threshold. This is because the animals need several days to acclimate to the new paddock conditions.~~

when rotational grazing is in effect, livestock move from one paddock to another at the end of the season. The farmer estimates the carrying capacity of the new paddock, and if the number of animals is greater than the carrying capacity, the farmer does an ordinary sale (if the season is fall) or extraordinary sale (if it is not fall) of animals

***Table 2****. Summary of management strategies in use by each livestock production system*

|  |  |  |  |
| --- | --- | --- | --- |
| Management strategy | **Traditional-oriented** | **Market-oriented** | **Environmental-oriented** |
| Spatial resource use | **Free grazing**  **OR**  **Rotational grazing** (animals are moved to another paddock at the end of the season) | **Free grazing**  **OR**  **Rotational grazing** (based on body condition of livestock) | **Free grazing**  **OR**  **Rotational grazing** (based on the SR of the paddock) |
| Ordinary sales:  Sell all male weaned calves and steers (except breeding males) | Yes (animals with **lowest OR highest** LW) | Yes (animals with **lowest OR highest** LW) | Yes (animals with **lowest OR highest** LW) |
| Ordinary sales:  Sell old cows | No | Yes (animals with **lowest OR highest** LW) | Yes (animals with **lowest OR highest** LW) |
| Ordinary sales:  Sell heifers and cows | No | Depending on the farmer’s workload capacity (animals with **lowest OR highest** LW) | Depending on the farmer’s workload capacity and on the state of the resource and animal welfare (animals with **lowest OR highest** LW) |
| Extraordinary sales in times of crisis:  sell livestock not intended for sale | No | Only when the body condition of livestock deteriorates (animals with **lowest OR highest** LW) | Only when the state of the resource is compromised, for animal wellbeing and grassland conservation (animals with **lowest OR highest** LW) |
| Breeding | Uncontrolled | Controlled | Controlled |
| Weaning | Natural  Early if the mother dies prematurely | Natural  Early if the mother dies prematurely or if the mother's body condition falls below a certain threshold | Natural  Early if the mother dies prematurely. |
| Feed supplementation | No | Yes | Only when the system is at or below the minimum herd size desired by the farmer. |

**OUTCOMES TO COMPARE BETWEEN LIVESTOCK SYSTEMS**

* Farmer wellbeing: farm income vs workforce
  + Income:
    - Sell of animals
  + Costs:
    - Food supplementation
    - Operating costs (e.g., farm infrastructure, equipment, etc.)
    - Workforce
* Animal welfare: body condition and pregnancy rate
* Resource level: resource quantity (total amount) and quality (bush encroachment)