Engineering Master's Degree of Institut Agro Montpellier
Domain: Agronomy; Agronomy and agri-food,
Option: Resources, Agricultural Systems and Development

Agrarian system and landscape dynamics in the production area of *Livanjski sir*, Bosnia and Herzegovina.

Emmanuel ARTUS & Anouk FRAISSE
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Emmanuel ARTUS & Anouk FRAISSE
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Résumé

Cette étude s'inscrit dans un ensemble de projets évaluant l'importance des systèmes d'élevage et leurs impacts sur les paysages dans la région des Balkans. Elle fait partie de Gingko (*Geographic Indications as knowledge commons*), un projet de recherche financé par l'ANR qui évalue le potentiel des IG en tant qu'outil pour la transition agroécologique, à travers leurs modes de gestion (gouvernance, contrôle, stratégie de commercialisation, ...) et leurs spécifications (alimentation des animaux, pâturage, ...).

Le canton 10 est caractérisé par un paysage remarquable incluant des poljés (vallées de plusieurs centaines de km au sein de formations karstiques), un réseau hydrographique souterrain qui les relie tous et une riche biodiversité, témoin d'une longue histoire d'activités pastorales et de transhumances nomades.

Le diagnostic agraire a permis de comprendre précisément les pratiques des agriculteurs et leurs interactions avec ce paysage. Il a mis en évidence un point de rupture dans la diversité des systèmes agricoles. Après la guerre (1992-1995), les anciennes fermes d'État de la Yougoslavie socialiste ont été privatisées. Il en résulte de grandes exploitations (plus de 500 vaches laitières ou 3 500 vaches allaitantes), qui coexistent avec de très petites fermes (environ 5 vaches). La plupart des agriculteurs élèvent des animaux pour la production de lait, vendu aux laiteries locales (qui produisent le *Livanjski sir* sous le label IGP). Au cours des 10 dernières années, des systèmes d'élevage pâturant pour la production de viande (veau ou agneau) se sont développés. L'analyse économiques de chaque type d'exploitation a mis en évidence de potentielles dynamiques d'évolution. Les grosses structures de production laitière, s'appuyant principalement sur des aliments fermentés (ensilage de maïs) sont les plus susceptibles de se développer, en taille et en nombre. Les petites exploitations et les éleveurs transformant le lait à la ferme disparaissent rapidement. Les systèmes pâturant pour la production de viande sont les plus susceptibles d'entretenir les zones les plus éloignées. Les quelques éleveurs laitiers qui mettent en place un pâturage d'été restent sur les terres les plus proches des bâtiments. En revanche, les fermes reposent de plus en plus sur l'utilisation d'aliments fermentés en vue d'augmenter la productivité des animaux, en viande comme en lait.

Les résultats montrent que (1) les pâturages des zones les plus reculées ont tendance à être abandonnés et les forêts prennent le pas sur les prairies, pouvant augmenter les risques de d'incendies ; (2) la production de *Livanjski sir* est confrontée à la fois à une pénurie de lait local (disparition des petites fermes) et à une perte de typicité ; et (3) ces dynamiques sont fortement dépendantes des subventions bosniennes, qui sont attribuées en fonction des litres de lait produits.

Dans ce contexte, le rôle du cahier des charges du *Livanjski sir* et des 4 laiteries locales qui le produisent est à questionner. Les politiques locales de développement rural peuvent être considérées comme un outil puissant pour influencer les pratiques des agriculteurs et leurs utilisations du paysage.

Mots clés : systèmes d'élevage – pastoralisme – pratiques des agriculteurs – production laitière – région karstique – poljés – indications géographiques

Abstract

This study is included in a range of projects assessing the importance of livestock breeding systems and their impacts on the landscapes in the Balkans region. It is part of Gingko (*Geographic Indications as knowledge commons*), a research project funded by the ANR assessing the potential of GIs as a tool for the agroecological transition, through their ways of management (governance, control scheme, marketing strategy, …) and their specifications (feeding of the animals, pastures, …).

Canton 10 is characterized by a remarkable landscape involving poljes (valleys of several hundreds of km formed within karstic regions), an underground hydrographic network which connects them all and a rich biodiversity, witness of a long history of pastoral activities and nomadic transhumance.

The agrarian system analysis provided a precise understanding of the farmers' practices and their interactions with this landscape. It highlighted a typing point in the diversity of farming systems. After the war (1992-1995), the former State farms of the socialist Yugoslavia were privatized. They result in huge operations (over 500 dairy cows or 3 500 meat cows), which coexist with very small farms (about 5 cows). Most of the farmers raise animals for milk production, sold to the local dairies (producing *Livanjski sir* under the PGI label). Over the last 10 years, grazing systems for meat production (veal or lambs) developed. The economic analysis of each type of farm unveiled potential development dynamics. Big structures for milk production, mostly relying on fermented feeds (corn silage) are the most likely to grow, in size and in number. Small farms and on-farm cheese producers are quickly disappearing. Grazing systems for meat production are the most likely to keep remote areas open. The few dairy farmers still relying on summer grazing remain on the lands the closest to the farm buildings. The meat production systems are the most likely to keep on grazing and maintaining the most remote areas. However, farms are increasingly relying on fermented feeds to increase animal productivity, both in meat and milk production.

The results show that (1) pasture lands on the most remote areas tend to be abandoned, and forests are taking over grasslands, increasing the risks of fires; (2) *Livanjski sir* production faces both milk scarcity (disappearance of small farms) and a loss of typicality; and (3) these dynamics are highly dependent on Bosnian subsidies, which are allocated according to the litters of milk produced.

In this context, the roles of the *Livanjski sir* book of specifications and of the 4 local dairies producing it are to be questioned. Local rural development policies can be seen as a strong tool to influence farmer's practices and their uses of the landscape.

Key words: livestock systems – pastoralism – farmers' practices – dairy production – karstic region – poljes – geographic indications

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List of abbreviations

AI: Agricultural Income

ACU: adult cattle unit

asl: above sea level

BiH: Bosnia-and-Herzegovina

BHS: local language (Bosniak, Hrvatski (Croat), Serb)

BoS: book of specifications

BS: breeding system

CS: cropping system

CZZS: The Centre for Environment

EU: European Union

FBiH: Federation of Bosnia-and-Herzegovina

FSA: Food and Safety Agency

GI: Geographical Indication

GAV: Gross Added Value

GIZ: German Development Agency

Ha: hectares

KM: convertible Mark (1 KM = 0,5 €)

L: litters

LU: Landscape Units

m: meters

NAV: Net Added Value

NGO: non-governmental organization

PDO: Protected Designation of Origin

PGI: Protected Geographical Indication

RS: Republika Srpska

PS: production system

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Introduction

The large and flat areas surrounded by mountain ranges, named *poljes,* is typical of karstic landscapes. Around Livno, no less than 15 of these *poljes* interact with each other through a remarkable hydrological network, both under and on the ground. To assess the impacts that humans have on this territory, a landscape study was initiated by a group of students from AgroParisTech in 2023. This document follows on from this study. It focuses on agriculture, and especially pastoralism which kept the landscape open and has been a main shaper of the area for centuries. To better understand this process, its evolutions and who are its stakeholders, it appeared logical to carry out a farming system analysis. Are analysed the interactions between the different landscape units and the diverse past and current production systems. It aims at drawing a portrait of agricultural practices and explaining how farmers use, shape, and transform the landscape.

For over 20 years, BiH has been engaged in a process of adopting EU norms and standards as part of pre-accession process. Thus, BiH shares a common perspective on the evolution of the EU legal framework of quality schemes such as Geographical indications[1] (GIs) which engaged different initiatives aiming at a better integration of the agroecological dimensions of the production. The study area counts two GIs for cheeses. The farming system analysis enables to measure the importance of those two GIs in the agrarian landscape of the study area. It aims at providing useful information on the potential role they could play in the evolution of agricultural practices. Indeed, this study is part of a wider research project entitled Gingko (*"Geographic Indications (GIs) as knowledge commons. Reassessment of current models of regulation and collective action in the context of agroecological transitions"*) and financed by the French ANR (Agence Nationale de la Recherche).

It was carried out together with a bachelor student in Sarajevo, who did a complementary analysis of the marketing and supplying strategies of both GIs. A more in-depth analysis of the agroecological performances of the farms will be carried in another document.

The combination of these different approaches – geographical, historical, economic and social – allows a precise understanding of the territory and, we hope, will help achieving better decision-making processes.

[1] A **geographical indication (GI)** is an intellectual property right. It protects a name of a product that has a specific geographical origin and owes its qualities and/or reputation to its particular origin (*Geographical Indications*, 2024).

Part I: Context of the research project

1. The research project

This document is the result of an internship carried out by 2 students, Emmanuel Artus and Anouk Fraisse, in their last year of engineering in agronomy, option “Resources, Agrarian systems and Development” at Institut Agro Montpellier. It lasted for 6-months and included a 5-months period of field work in Canton 10, BiH. It was realised along with Amila Slijepčević, a food-processing student from the Faculty of Agriculture and Food Sciences of Sarajevo. She joined the study for 3 months and wrote a report of her own, focusing on dairies and cheese production. Both documents are to be seen as part of the same study. They focus on the area of production of two GIs: the PDO[2] *Livanjski izvorni sir* and the PGI *Livanjski sir*.

This document follows on from a landscape study initiated by a group of 15 students from the master "Forest, Nature and Society International Management” of AgroParisTech in March 2023. Their study was conducted in partnership with *Centar za životnu sredinu* (CZZS), an ecological NGO of BiH and AIDA, a French NGO promoting actions for protecting biodiversity in agricultural landscapes. François Lerin (of AIDA), Orianne Crouteix (UMR Telem, Aix Marseille University and lecturer at AgroParisTech) and Jeremy Vendé (AgroParisTech) were part of the supervising team of this collective internship. They are still involved in studies occurring in the Balkan region and were part of the team supporting our study. Alen Mujčinović, lecturer at the Faculty of Agriculture and Food Sciences of Sarajevo, was also part of the supporting team.

This internship was supported by UMR (Mixed Research Unit) Innovation, at CIRAD in Montpellier, France and supervised by Claire Bernard-Mongin (UMR Innovation, CIRAD). Claire Aubron (UMR Selmet, Institut Agro Montpellier and lecturer) was our thesis advisor.

It is part of Gingko, an interdisciplinary research project funded by the French National Research Agency (ANR). It is divided into 4 work packages (WP):

- WP1: "Knowledge ecosystems and models of collective action and regulation for GIs in France and Europe", will analyse the diversity of models of collective action and regulation supporting GIs in Europe, with a particular focus on the role of third-party certification systems in agroecological transition dynamics.
- WP2: "Agroecological transitions and GI sustainability strategies: concepts, methods and case studies", will be based on around 30 case studies covering various agroecosystems (soil, climate conditions, productions as wine, dairy products, meat, vegetables, ...) in France and abroad.
- WP3: "Typology of GI transition trajectories and their territorial and legal/regulatory determinants", will draw up a typology of transition trajectories and explanatory scenarios, considering legal determinants (intellectual property, land management, landscape protection, agroecological infrastructures, ...), local dynamics of adaptation (at individual or collective level), and the associated governance mechanisms.

[2] According to the EU GI legal framework, GI protection distinguishes between a ‘protected designation of origin’ (‘PDO’) or a ‘protected geographical indication’ (‘PGI’):

- PGI: a given quality, reputation or other characteristic of the product is essentially attributable to its geographical origin, and at least **one of the production steps takes place in the defined geographical area**.
- PDO: the quality or characteristics of the product are essentially or **exclusively due to a particular geographical environment**.

(*Geographical Indications*, 2024)

– WP4: "Synthesis and dissemination", will synthesize the results, with the aim of contributing to current policy debates in France, but also at European and international level through the FAO/OriGin expert group ("Sustainability Strategies of geographical indications").

Our internship was carried out as a part of the WP2 (and further on, WP3).

2. Research questions, hypothesis and frameworks

2.1 Research questions

To assess whether the GIs have a positive influence on the implementation of agroecological practices on the production systems of Canton 10, it is important to first describe these production systems and understand their functioning. To do so, their trajectories must be studied as they shaped – and were shaped by – the landscape. It enables a precise description of the interactions between farms and their territory and might as well provide clues for future dynamics. It also allows to have an overview of the productions in the area – meat, milk or cheese – and of the importance of both GIs within these productions. Thus, our research is built around the following problematic:

What are the characteristics of the different production systems in Canton 10, their trajectories, and their interactions with the landscapes?

To better address this problematic, we divided it into 3 research questions:

(1) What are the changes, and the drivers of these changes, in the agrarian landscape of Canton 10?
(2) What are the current production systems and how the landscape shape them as well as how do they shape the landscape?
(3) What are the technical, economic, and agroecological performances of the production systems in Canton 10?

These questions are based on the following hypothesis:

H1: The study area is a pastoral area whose agriculture has been affected over the last 50 years by wars, a socialist regime and the creation of new national borders. A long period of recovery led to the current diversity of farms, with a focus on livestock farming.

Land is divided between public and private lands since the socialist Yugoslavia. The war (in 1992-1995) triggered a rural exodus and an agricultural decline which is still visible today. In recent years, private investments led to the emergence of semi-industrial dairies and breeding systems based on concentrates and corn, while the number of pastoral systems has been decreasing, leaving room for afforestation.

H2: Canton 10 harbours farms managing hundreds of animals fed with corn and concentrates as well as farmers raising a few cows relying on summer pastures. A huge gap in the economic performances of these farms exists.

Some farmers raise a consistent number of animals in stable (among others, cows for milk production processed in the dairies under PGI label). They feed their animals with concentrates

and corn to improve the milk production and manage several hectares. Medium farms (around 10ha) raise fewer animals fed exclusively in the region through pastures, straw, and hay. They produce milk for the PDO *Livanjski izvorni sir* and/or the PGI *Livanjski sir*. Subsistence farmers only have a few animals and a few hectares (around 2 ha), used for milk production and household uses.

H3: The farms are located in different parts of Canton 10 and use specific parts of the landscape. It leads to different practices for managing the herds and the crops.

Flat areas (called poljes) are used for crop production (cereals, potatoes, vegetables) and hay if they are not flooded. Some animals occasionally pasture in the poljes, especially during wintertime. Summer pastures are located on slopes and karst plateaus. Steep slopes are mainly occupied by forests. Moreover, wider farms and semi-industrial dairies are mainly located in Tomislavgrad and Livno. Glamoč and Kupres are higher areas with medium size farms. The northern part of Canton 10 is mainly characterized by subsistence agriculture.

2.2. Frameworks

We define and use several concepts, or frameworks, to answer our research questions and test our hypothesis. They give theoretical guidelines to our methodology.

Agrarian system

An **agrarian system** (Figure 1) was defined by Mazoyer and Roudart (1997) as *"the theoretical expression of a historically constituted and geographically localized type of agriculture, composed of a characteristic cultivated ecosystem and a defined productive social system, the latter allowing the fertility of the corresponding cultivated ecosystem to be sustainably exploited"*. In other words, the agrarian system is composed of different elements – plants, animals, equipment, farmers, etc referred to as "cultivated ecosystems" and "productive social system" – that interact between each other. These interactions are the result of the evolution of agricultural practices and are anchored in a delimited territory, the GIs territory in our case. Indeed, it is composed of several and distinct production systems, resulting from differentiation mechanisms throughout history. They are shaped by political regimes (for example the socialist Yugoslavia), agrarian reforms (implementation of subsidies), rural development projects (registration under GI labels) as well as social relations, exchanges and access to resources.

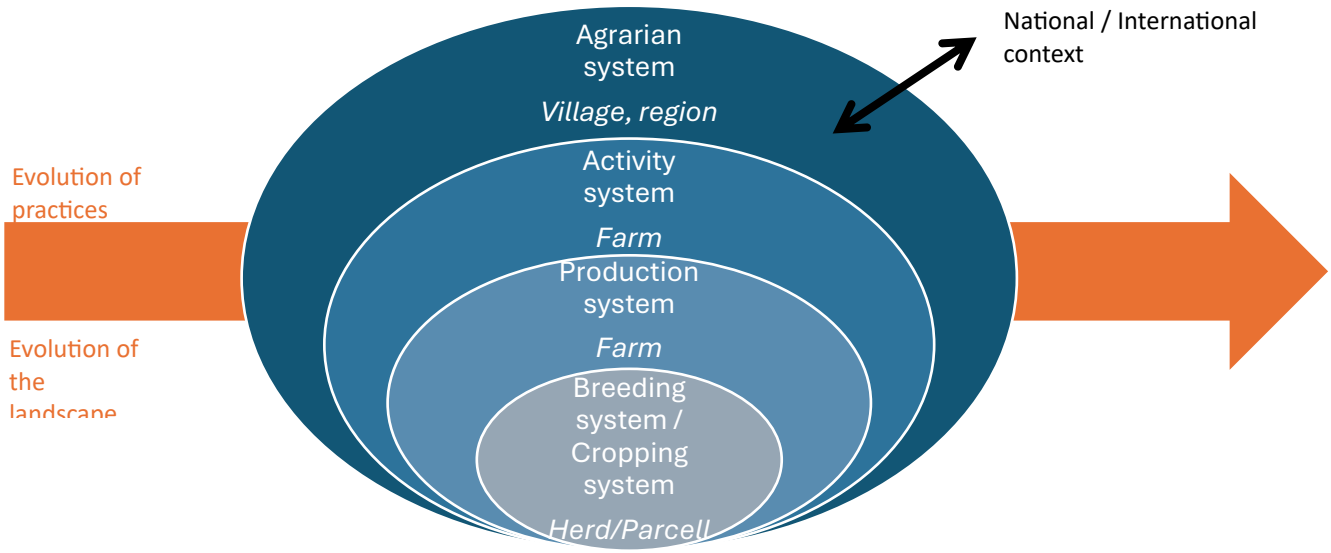


Figure 1:Concepts and scales of an agrarian system. Emmanuel Artus and Anouk Fraisse.

As an agrarian system is defined in a specific **landscape**, it is important to also define it. We understand landscape as an area with a specific set of biotic and abiotic characteristics. It *"can be conceived as the support of original information on numerous variables, relating in particular to the production systems and whose superposition or proximity reveals or suggests interactions."* (Cochet et al., 2007). At the scale of breeding and cropping systems, some elements – elevation and topography, the presence of water drainage systems, corn, large areas of grassland on karst formations, etc – give clues about farming practices. The combinations of these elements provide information on the potential relations between these systems and draw a wider picture at the scale of the agrarian system. It can also inform about the evolution of practices, through shrub encroachment for example. Indeed, there is a *"dialectic relation between the farming practices leading to a certain landscape and the landscape as a way of expressing practices"* (Chantal Blanc-Pamard, quoted in Cochet et al., 2007).

The concept of **production system** is relevant at the farm scale, to describe farming practices. Within an agrarian system, a production system encompasses a set of farms that have the same range of resources, placed in comparable socio-economic conditions and that practice a comparable combination of productions. In short, *"In the typology of farms thus constructed, each type is represented – and modelled – by one and only one production system."* (Cochet, 2011). Its components, and the decision rules of the farmer, must be understood for themselves.

A **cropping system** is defined by one or several plots managed in the same way – rotation and technical itinerary are the same (Dedieu et al., 2006). A **breeding system** is defined by a herd (or a part of it), raised in the same way and for the same purpose (Dedieu et al., 2006). Except for very specialized farms, a production system is the combination of several cropping and breeding systems.

A production system can be part of an **activity system** (Cochet, 2011). Indeed, in some cases, agricultural activities are not the only activities generating income for the farmers. Another type of job can be carried out outside of the farm, from being an agricultural employee elsewhere to being a part-time nurse or working at the veterinary station. It is important to consider the activity system when it can help explain the why and how of the productive process in agriculture.

2.3. Materials & method

Agrarian system analysis

An **agrarian system analysis** comes down to asking the following questions: ''In this region, who are the farmers? What are they doing? How? And why?''. As obtaining these pieces of information answers well our research questions, our study will take the form of an agrarian system analysis. It is divided in two main steps:

(1) a landscape and history analysis of the territory, tracing the general evolution of production systems in the area as well as questioning the evolution of the GIs and their impacts on the evolution of production systems,
(2) a description of the diversity of the production systems in the area, with a focus on their access to the territory resources (fodder autonomy, pastoral dimension, access to water, ...) and their comparative analysis (economic and agroecological performances).

It combines a literature review (scientific articles, books, documentaries, ...), field observations and exchanges with local people. Indeed, it is a stakeholder-based method, meaning that most of our work consisted of semi-structured interviews, especially of farmers – but not only.

Semi-structured interviews are a data collection technique. It takes the form of a continuous discourse in which the order of questions asked can be more or less determined in advance, according to the interviewee's responsiveness. The interviewer asks a few points of reference and follows the flow of ideas of the interviewee.

Interview guidelines have been designed to ensure that we don't miss any essential point. There is one for each type of interviews we carried out: historical interviews (Annex 1), production systems interviews (Annex 2), dairy's interviews (Annex 3) and agriculture representative's interviews (Annex 4). They are divided into 5 main parts:

(1) Presentation of our study in a few words,

(2) Open-ended questions about the person's profile and trajectory: in this part, we go from the personal situation to a wider scale, asking about neighbours' practices,

(3) Specific questions about the information we are looking for depending on the interviewee's profile (economic data, cheese production, PDO or PDI specification),

(4) End of the interview: to leave room for the interviewee to ask questions and then ask for useful contacts (the interviewee themself and acquaintances) and inform them about the presentation of our results.

These guidelines were also a working tool for our translators, to introduce us and the study we are conducting but also to help them understanding the type of information we wanted to collect.

As we were 2 interviewers, one of us led the interview and was careful that the guidelines were followed, while the other one was taking notes. Each interview was transcribed into a digital document and was attributed a specific code, so that interviews are easy to find and locate on a map.

The **sampling** for the historical, dairy's and agriculture representative's interviews is based on contact gathered through different sources of information according to the triangulation principle (De Sardan, 2003), to avoid being tied to a single point of view. After these interviews and landscape observations, a pre-typology was made up. We selected the interviewees for production systems so as to have enough interview for modelling these types. Agricultural data from the Canton 10 and its different municipalities, contacts given by official representatives (FAO in Sarajevo, FSA in Mostar, ...) and contacts given by the interviewees were collected.

Organisation of the study

Our internship lasted for 6 months. The first month, in Montpellier, was dedicated to personal research on the general context of the study and the preparation of the field work (Figure 1). The next 4 months were dedicated to field work, in Livno, and the last month to writing our master thesis. In Livno, the first week was spent with François Lerin and Claire Bernard-Mongin. François Lerin came back for one week in July. Every month we held a meeting with Claire Bernard-Mongin, and every two months with Claire Aubron.

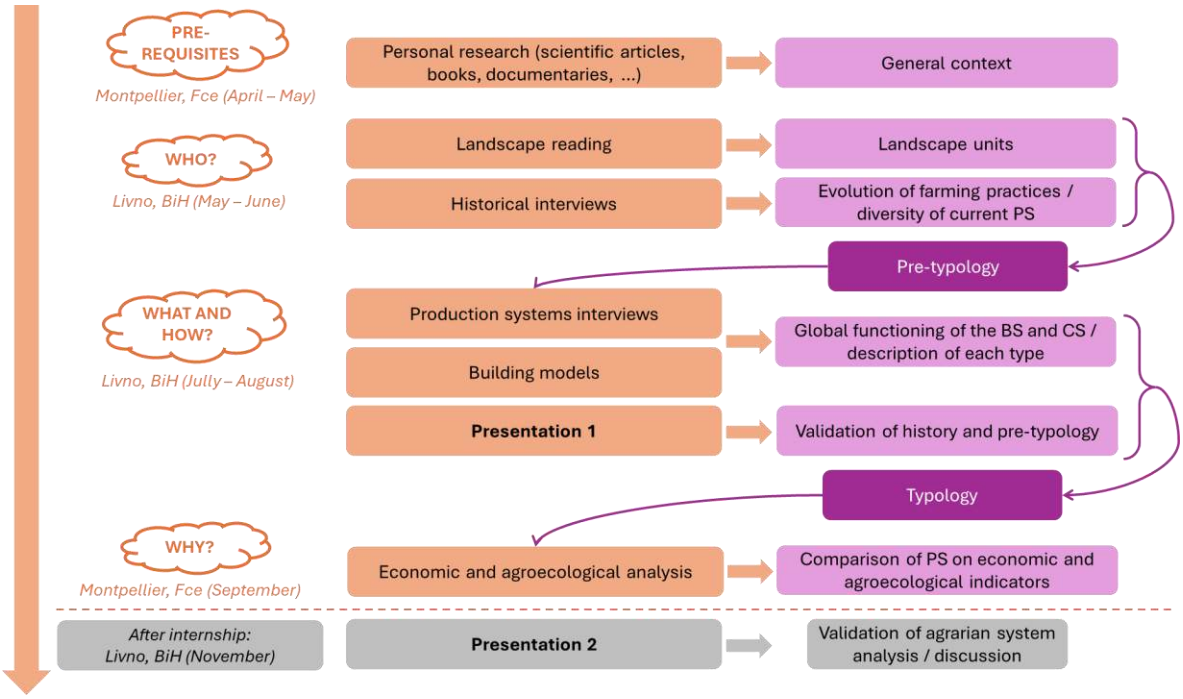


Figure 2: The different steps of our agrarian system analysis. Emmanuel Artus and Anouk Fraisse.

The **landscape reading** consisted of the observation of the study area to identify landscapes units (areas with the same characteristics, as defined earlier). The landscape reading was carried out during the whole period of the internship, with a focus at the beginning of the field work period (Figure 2). Itineraries were defined for each day and notes were taken. This step gives a first look at the region's agriculture without bringing in the vision of local stakeholders.

To understand how landscape units and their uses changed throughout the years, a **historical analysis** was carried out for 2 months (Figure 2). It was mainly based on semi-structured interviews with elderly people who could relate historical events over the last 30 years (retired farmers for example). 50 interviews were realised. They enabled us to draw up a timeline of the main differentiation processes in agricultural practices and policies in Canton 10 and to locate them on the landscape (pasture areas that were used before but not anymore, for example). At the end of this step, a pre-typology of the current production systems was established.

The **description of the production systems** (from our pre-typology) was also based on semi-structured interviews of farmers (8 from the historical analysis were re-used and 16 new ones were realised). They enabled us to have a clear understanding of the current production systems – of the breeding systems and cropping systems composing them. Their location on the territory and their uses of the landscape units were also described.

At this point of the study, some production systems were chosen to be **modelled**. They were chosen regarding their trajectories, their impact on the landscape and their link with the GIs. In the pre-typology of farms constructed, one type of farm is represented - and modelled - by one and only one production system. It means that one production system is built upon several farms (corresponding to the same type). Further interviews (15, with more directive questions) were carried out on the chosen production systems to collect more precise data: selling prices, cost of fertilizers, importance of subsidies in farmers' income, quantities of feed given to the animals, ...

A presentation of the first results was done in Livno, at the beginning of September (Figure 2). Its aim was to validate our understanding of the evolution of agricultural practices towards the current production systems (pre-typology) as well as their global functioning (animal feeding,

hectares managed, landscape units used, ...). 15 persons were present, half of them being farmers.

The **economic analysis** enabled us to compare the economic performances of the production systems which were modelled. To do so, we calculated some indicators:

(1) The Gross Added Value (GAV): GAV = GP – IC, with GP being the gross product (or the number of sales in one year) and IC being the intermediate consumptions (or the wealth "destroyed" in one year to obtain the gross product),

(2) The Net Added Value (NAV): NAV = GAV – depreciation, where depreciation is the annual loss in value of the equipment and buildings (tractors, barns, drills, ...),

(3) The agricultural income (AI): AI = NAV + subsidies – wages – interests – taxes, which corresponds to the amount of money left for the owners of the farm (most of the time, family members).

These indicators were then reduced to 1 ha, 1 animal or 1 working day, to facilitate the comparison of the different production systems.

To understand what farmers can generate through their production system, we build a graph of the agricultural income depending on the surface (Figure 3). It is calculated for one familial worker. The y-axis represents the agricultural income in KM/familial worker; the x-axis represents the surface in ha/familial worker. The red line represents the minimal wage, 600 KM/month in FBiH (or 7 200 KM/year). D2 is calculated with the maximal surface that can be managed for 30 working days per month (with 1 Wd = 8hrs). The maximal surface is calculated with the most labour-intensive period of the year (because it limits what farmers can do). Everything that is above requires more than 30 days per month, which we consider impossible. D1 is calculated with the minimal surface enabled by each production system (its method of calculation varies from one production system to the other, further explanations are given in the economic analysis). Thus, one production system exists between D1 and D2; the blue line represents all the potential farms that compose each production system. Some people manage less than the maximal surface (for example, D3).

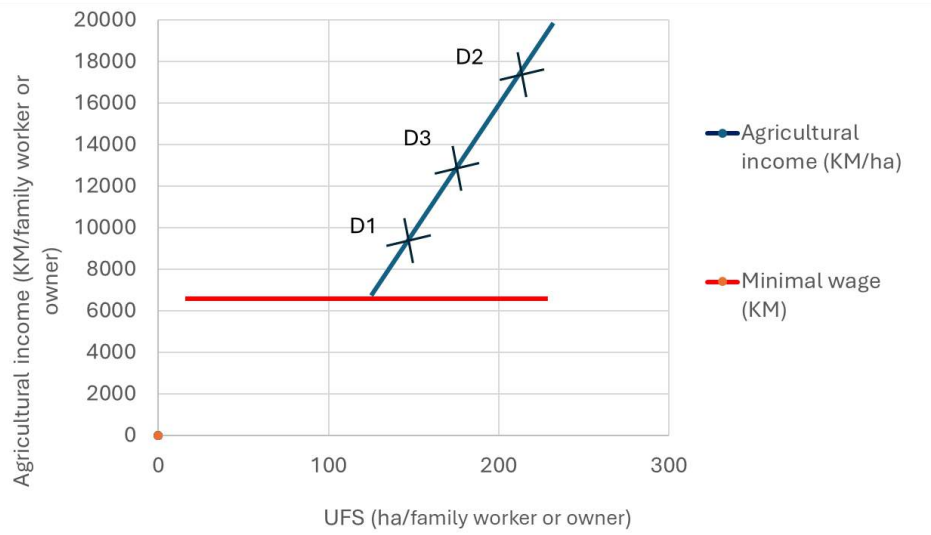


Figure 3: Graph presenting the agricultural income (KM/ha) for our model. Emmanuel Artus and Anouk Fraisse.

This part of the study was finalized in Montpellier, in France. It will be the object of a second presentation in Livno, in November, after our graduation and as a continuation of the project (Figure 2).

All these steps were supplemented by personal research and interviews of other actors of the territory: employees from the different municipalities, from local dairies, from the office of forest management, … In total, 84 interviews were carried out (Figure 4). They are referred to with the code name Type-City-Number (type being historical interview (H), technical interview (T), dairy (D); City being the three first letters of the municipality). For example, H-Liv-01 is the first historical interview carried out in Livno.

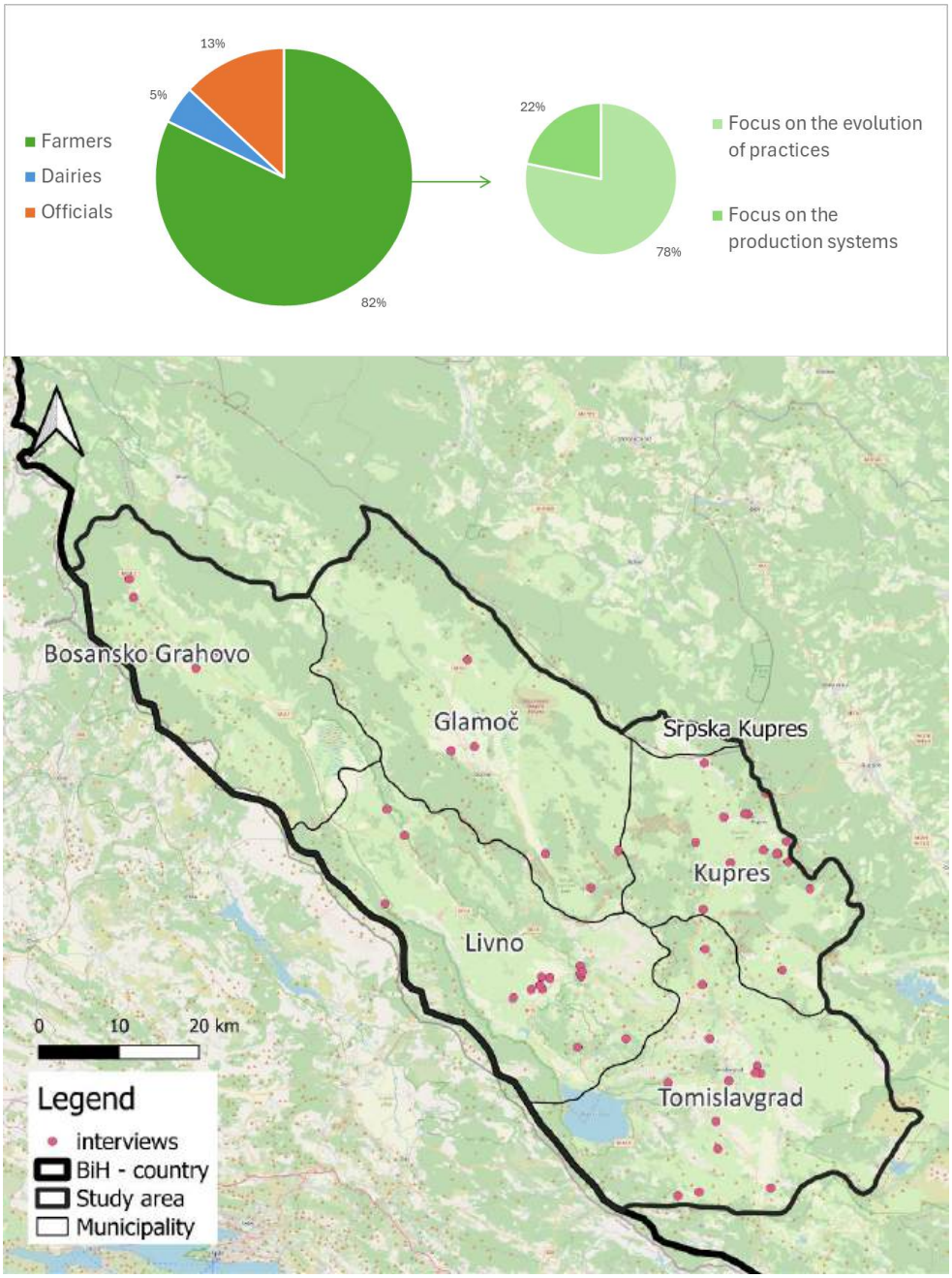


Figure 4:Top: types of interviewees and interviews. Bottom: location of the interviews, QGis, Emmanuel Artus and Anouk Fraisse.

Part II: Landscape analysis of the study area

1. Delimitation of the study area

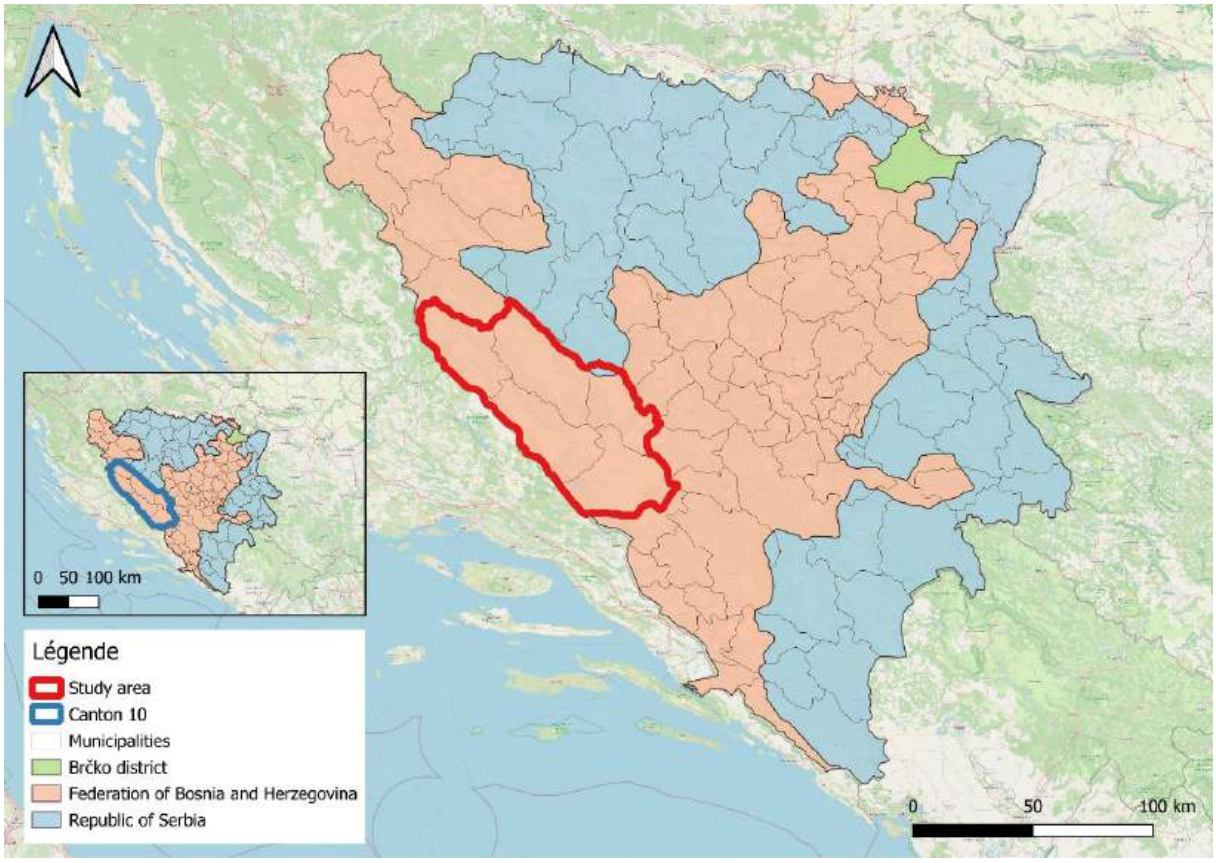


Figure 5: Delimitation of our study area. Realised with QGis, data from the University of Banja Luka.

BiH is divided into 3 administrative parts (Figure 5): Federation of Bosnia and Herzegovina (itself divided in 10 cantons, including Canton 10), Republika Srpska (also divided in 7 administrative areas) and Brcko district (independent entity). Cantons are divided into municipalities.

Canton 10 is located on the eastern part of BiH. It is divided in 6 municipalities: Livno, Tomislavgrad, Kupres, Glamoč, Bosansko Grahovo, and Drvar. All of them are part of the milk collection area for the PGI *Livanjski sir*. For our internship, we decided to take the municipality of Drvar out of the study area because its landscape differs from the other municipalities: narrow valleys, mountains, steep slopes, … Moreover, of the dairies we interviewed, none said that it was collecting milk there (as it is far from Livno and on the other side of a mountain pass). The northern part of Kupres, which belongs to Republika Srpska, is also included in our study area. It forms one continuous landscape with Canton 10, and it is part of the milk collection area for the PGI. The production area of the PDO *Livanjski izvorni sir* is located in Livno municipality, which is included in our study area.

This delimitation (Figure 5) will enable us to have an overview of the production systems involved (or not) in both GIs.

2. General organisation of the territory

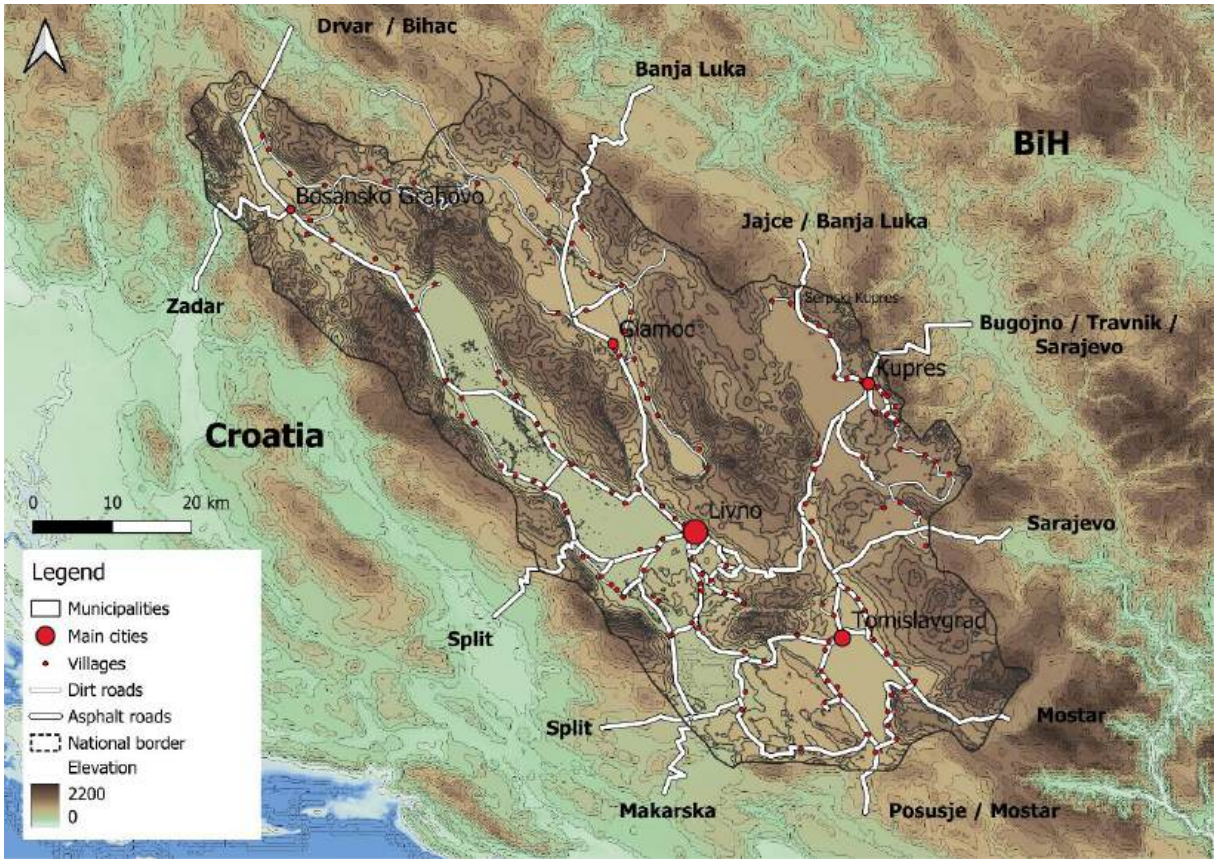


Figure 6: Main cities and roads of the study area. Realised with QGis, data from the University of Banja Luka.

Our study area is located in a mountain range, called the Dinaric Alps – or the Dinarides, which is part of the Alps. Its elevation varies between 700 m asl and 2200 m asl (Figure 6). It is composed of valleys (wide and flat areas without contour line on Figure 6 – called karst poljes), peaks and plateaus. It is divided into 6 municipalities. The main cities are Livno, Tomislavgrad, Kupres, Glamoč and Bosansko Grahovo. They concentrate most of the economic activity and people commute there from their home villages for work. The villages around are located along the poljes. Some are organized on either side of a lone road, located on thin polje brinks. They are then called "street villages" (Figure 7). Some other villages, located on wider polje brinks, aren't linear and form groups of houses. They are called "clustered villages". Street villages are predominant on the landscape.

All these inhabited areas are connected by roads (Figure 6); the main ones are asphalt roads whereas secondary axes are often dirt roads. The most remote villages are only accessible with 4-wheels cars. The main roads connect the area with central Bosnia on the North and Dalmatia (Croatian coast) on the South (Figure 6). These roads are very touristic, either during summer to go the sea and in winter to go skiing. Theses axes are very important in the sales of agricultural products. Better connection with Dalmatia can be observed. Indeed, only high mountain passes, and winding roads allow to go to the northern part of BiH. *Livanjski sir* is, for example, sold on the side of the road that goes from Bugojno, BiH to Makarska, Croatia all summer long.

Figure 7: Street village in Dobranjsko polje, Canton 10, BiH. Anouk Fraisse.

3. Local climate

The climate of our study area is the sub-mountainous and mountainous climate. It is characterized by cold temperatures in winter (-4 to -7°C in January) and mild temperatures in summer (9 to 14°C in July). However, there are large differences depending on relief and altitude.

Indeed, the influence from the Adriatic Sea brings to higher summer temperatures and less rainfalls than for more inland areas. Elevation differences also create local variations. To explain these differences at the local scale, we used the Köppen-Geiger climate classification (Figure 8). It is based on thermal (temperatures) and pluviometry (precipitations) indicators calculated over several years to differentiate climate types.

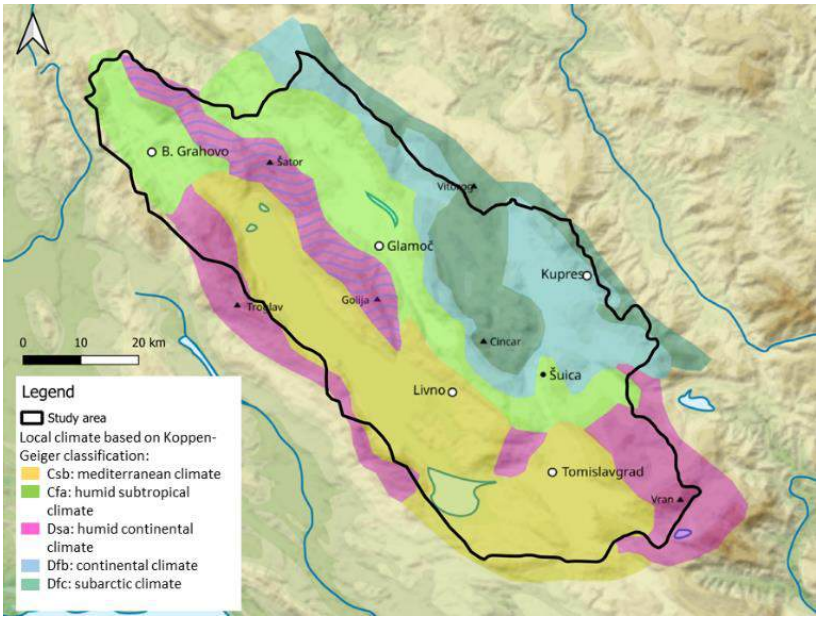


Figure 8: The local climates of the study area. Realised with QGis, data from the Federal Hydrometeorological Institute.

The local climate in Livno and Tomislavgrad municipalities is more under the Adriatic (or Mediterranean) climate regime (Figure 10). Summers are more likely to be dry and winters to be mild and wet – the average temperature of the coldest stays above 0°C. This climate leads to a mix of northern European elements of grasslands and forest, as well as plants characteristic for the Mediterranean coast (Kulijer, 2012). Indeed, vegetation shows adaptation to drought, especially on the plateaus, where the water leaches and is not retained due to the limestone substrate.

Aromatic plants as thyme were observed on the plateau behind Livno (Krug planina). This is what made the reputation of the area for pasturing and cheese-making.

Forests of oak trees were also present on the slopes surrounding the poljes of Livno and Tomislavgrad. As summers are dryer and hotter than in the rest of the study area, the vegetation dries from early July until September, when the rain comes again (Figure 10). Cooler temperatures make the vegetation growth to start earlier than in other municipalities. In Kupres, for example, there is no vegetation until May when it can start in March in Livno. Snow and wintertime also come earlier in Kupres.

"Here in Livno, wind and sun make that there is all year round some vegetation available. Snow is not everywhere. That's why horses are so big, even at the end of winter. In Kupres, snow is sometimes everywhere..." (H-Liv-01)[3].

The mountains surrounding Livno and Tomislavgrad are characterized by **humid continental climate**. It is located higher in altitude than Livno – above 1500 m asl – so temperatures are lower, especially in winter. However, summers are still hot. Their topography creates cloud accumulations and rainfall are occurring all year round.

The continental climate describes well the municipality of Kupres (Figure 8), where summers are warm, and winters are cold. Indeed, the influence of the Adriatic Sea is not significant; temperatures are not moderated by the sea. Moreover, it is higher in altitude than Livno and Tomislavgrad (1175 m asl against 745 m asl and 800 m asl). Average temperatures are thus colder (Figure 10). Rainfall occurs all year round and comes in the form of snow in winter, as the coldest months have an average temperature below 0°C. It results in a vegetation cover which is shorter, but which is greener, especially in summer, than in the rest of the study area. Aromatic plants were less observed in this area, just as there were fewer oak trees in the forests. It also means that harvests are done later in Kupres (about 2 weeks) than in Livno, for example. A strong prevailing wind, called the Bura, characterize this area. It blows from the N-NE, bringing in cold air masses. There even is a famous saying in BiH: *"Puše kao na Kupresu"* which means "It's windy as in Kupres"! Several tree lines, perpendicular to its course, indicates the presence and strength of the Bura (Figure 9).

Figure 9: Tree hedges in Gornji Malovan (Kupres). Google maps.

[3] (H-Liv-01) is the reference of the interview from which the quote comes from. The first letter indicates the type of interview (H for historical, T for technical, ...). In the middle is the municipality (Liv for Livno, Gla for Glamoč, ...). Then is the number of the interview (05 for the 5th interview carried out in Livno).

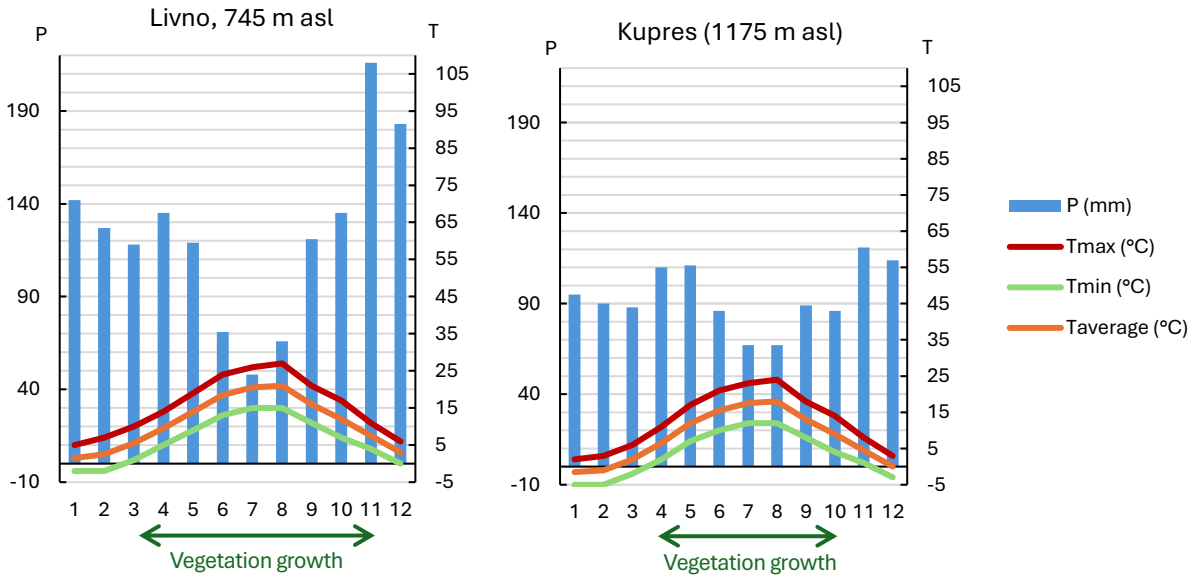


Figure 10: Climate charts of Livno and Kupres, with P=2T. Data from Meteoblue - climate models.

The mountains all around Kupres are characterized by a **subarctic climate** (Figure 8). Winters are long and cold (up to 7 months below 0°C) whereas summers are short and warm (only 3 months above 10). The main difference with the polje of Kupres is that average temperatures decrease because of a higher altitude.

Finally, the municipalities of Glamoč and Bosansko Grahovo are characterized by a **humid subtropical climate**. It is a warm and rainy climate with hot summers. The rainfall peak happens in summer and comes in the form of thunderstorms. There is no dry period. This area is transitional between the Adriatic climate zone of Livno and Tomislavgrad and the continental climate zone of Kupres. Aromatic plants are still quite numerous, and the first snows come in later than in Kupres.

4. Geology of the Dinaric Alps and hydrology of karst formations

4.1. Geological origin of the karst formation

The study area is located on the Dinaric Alps. They are a mountain range in Southern and Southcentral Europe, separating the continental Balkan Peninsula from the Adriatic Sea (Figure 11). They stretch from Italy in the northwest to Albania in the southeast, going through Slovenia, Croatia, BiH, Serbia, Montenegro, and Kosovo. They are mainly composed of sedimentary rocks, formed by seas and lakes that once covered the area. During the Alpine earth movements that occurred 50 to 100 million years ago (Adriatic Microplate collision with European plate), immense lateral pressures folded the rocks in parallel ranges, resulting in the Dinarides mountain range (Hrvatović, 2006). They are oriented from North-West to South-East and are divided into different geological units: the Dinaric carbonate platform, the Bosnian flysch, the Dinaric ophiolite zone and Vardar zone.

Figure 11: Location of the Dinaric Alps within the Apls mountain range. Realised with QGis.

The study area is part of the Dinaric carbonate platform. It is largely composed of limestones (green on Figure 13) and, to a fewer extent, dolomites (light purple on Figure 13) which were deposited during Mesozoic (Hrvatović, 2006). The dissolution of these carbonates rocks, via water and carbon dioxide, results in a karst formation. It reacts according to the following equation (Gilli, 2011):

$$(1)\quad CO_2 + H_2O + CaCO_3 \text{ (carbonate rocks)} \rightleftharpoons Ca^{2+} + 2\,HCO_3^-$$

Limestones are worn away very slowly; altered particles are blown away by water and winds faster than they accumulate. It results in the formation of shallow soils and numerous outcropping rocks. On the opposite, dolomites are worn away up to ten times faster than limestones and therefore produce a greater number of altered particles. Thicker soils with less rockiness are formed.

The formation of karst landscape is thus favoured by water; its abundance, its CO_2 content, its temperature (the lower the richer in CO2) and the water-rock contact period. It results in a wide range of shapes and characteristic elements (Gilli, 2011):

- rocky surfaces shaped by water alteration (relatively shallow soils, lapiés),
- enclosed depressions (dolines and karst poljes),
- caves and chasms,
- the disappearance of surface streams into underground hydrographic network (ponors, resurgences, underground rivers, ...),
- and a low amount of water sources.

The presence – or absence – of these elements varies from one karst formation to the other.

As the municipality of Kupres belongs to a geological unit richer in dolomites, it differs from the rest of the study area (Stepišnik, 2014). Indeed, when observing the landscape, it has fewer outcropping rocks. Several lime extraction sites (coming from dolomite) can be seen on the road to Vukovsko polje and around the city of Kupres (Figure 12).

Figure 12: Dolomite extraction site, municipality of Kupres, Canton 10, BiH. Anouk Fraisse.

Even though there are some differences, the whole study area shares the same hydrography characteristics, very typical of karst formations. The subsoil is dug with cavities that were formed thanks to the dissolution of carbonate rocks – limestones as well as dolomites. Most of the water circulates through an underground network of caves and rivers. It infiltrates via ponors, located on the surface of karst formations.

Depressions of various sizes, called dolines, form by the dissolution of carbonate rocks or when underground cavities collapse (Gilli, 2011). When this phenomenon is associated with tectonic movements of long periods, very flat and closed valleys appear. These valleys are called poljes. They are filled with sediments (light yellow on Figure 13) which accumulated through time thanks to successive floodings and water deposition. They are the major characteristic element of our study area. Indeed, the Dinaric Karst poljes are the largest continuous karst area in Europe (Sackl, 2014).

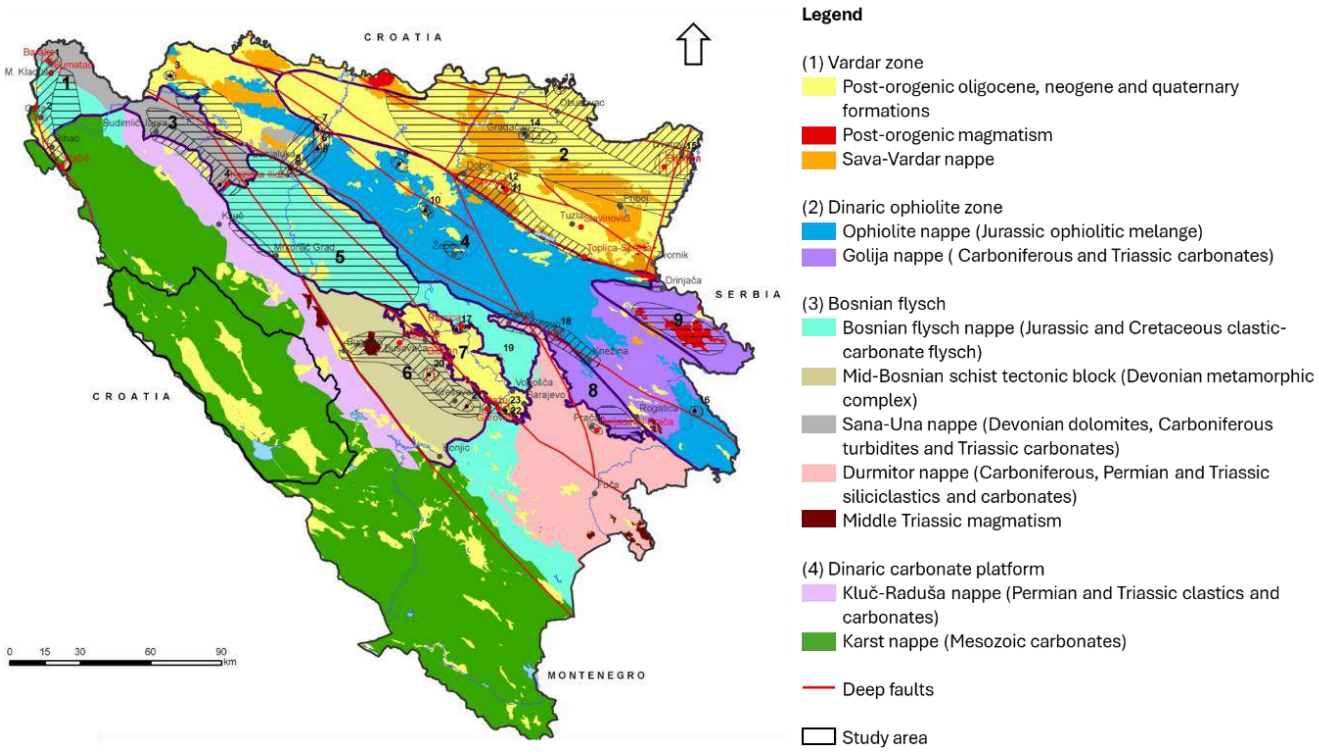


Figure 13: Geological map of BiH. Data adapted from Hrvatović, 2006.

4.2. Hydrology of the karst formation

As said before, karst formations have a very complex hydrography network, both on the surface and underground (Figure 14).

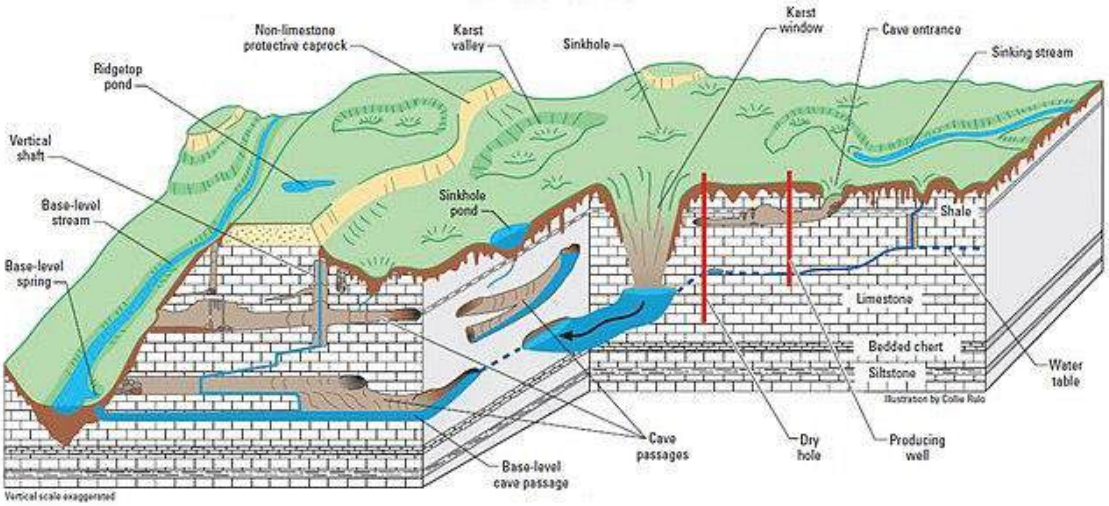


Figure 14: The hydrography of well-developed karst formations. Figure from Currens, Kentucky Geological Survey, 2001.

On the surface, there are **streams, rivers, and lakes**. Streams and rivers only form in the poljes and are more or less meandering, depending on the gentleness of the slope. They are surrounded by vast areas of porous carbonate massifs and plateaus without surface watercourses (Sackl, 2019). Some steep-sided rivers, rather straight, form canyons, as the Šujica river. Streams and rivers go out of rocks through springs, mainly located on the brinks of karst valleys. Most of the time, these springs are **resurgences**. Indeed, the surface water go underground at some higher altitude and go out again at lower altitudes, forming underground rivers. It is directed towards several low points where it disappears into **ponors** (Figure 15, photo 1 and 2) or **estavelles**. Both represent fissures in the karst massif through which the water sinks underground (Bonacci, 2013), draining rivers, streams and even lakes. Estavelles are particular types of ponors that can serve as a sink or as a source of water. Indeed, during the wet period, the groundwater level is higher than the level of the estavelle and the water rises to the surface, according to the principle of communicating vessels (Bonacci, 2013).

It means that the abundance of surface water is highly dependent on the underground water level, and thus on the season. Indeed, riverbeds are wider in winter and narrower in summer – sometimes even dry (Figure 15, photo 3 and 4). Some of them are permanent and other only forms in the wet period. Alike rivers, lakes get wider during wintertime. When the rivers flow increases a lot, supplied by heavy precipitations or snow melt, it can exceed the capacity of absorption of ponors and form a seasonal lake (Figure 15, photo 5). It can also happen when ponors are blocked by the accumulation of sediments or plant residues. It lasts until the water pressure is strong enough to push them back (Gilli, 2011). Even though the majority of lakes is seasonal, some are permanent. These are mainly artificial lakes, such as the Buško Blato Jezero (5 500 ha) and the Mandek Jezero (), both located in the municipality of Livno.

Figure 15: (1) Ponor in Kupres. Anouk Fraisse; (2) Ponor in Tomislavgrad. Anouk Fraisse; (3) Šujica river in spring. Anouk Fraisse; (4) Šujica river in summer. From Sackl, 2014. (5) Livanjsko polje, flooded. From Sackl, 2014.

The water regime in the study area, especially the municipality of Livno, was heavily modified by human hydraulic infrastructures. For example, the Buško Blato Jezero, one of the largest accumulation lakes in Europe, was created during Yugoslavia. It aimed at supplying a hydraulic power plant in Croatia, which was then part of the same country. It started in 1974 and is still working today. Along with the construction of the dam and the channelling of rivers, draining canals have been built in Livno (as well as in Tomislavgrad). This construction changed the soil properties. Indeed, before this construction, it was a swamp – "*blato*" means "swamp" or "mud" in BHS. Seasonal floodings were maintaining soil fertility through the deposit of sediments brought by water. It is not the case anymore and *"now, the clay is very close to the top layer"* (H-Liv-01). The second part of this project consisted in building other canals, to irrigate and bring back the soil fertility with water from the lake. However, due to some miscalculations in the depth of the canals, it has never been functioning (H-Liv-01). The local climate was also modified by the

lake: *"Before its construction, there were 2 m of snow during wintertime… but now, it is only 30 cm and that's it"* (H-Liv-03).

The underground hydrographic network is composed of fissures, caves and underground streams (Figure 14). They connect all the poljes (or karst valleys) of our study area (example of Livanjsko polje, in Annex 5:). They feed major river basins: the Cetina river basin (flowing into the Danube, ending its course in the Black Sea) on the North and the Pliva river basin (Adriatic Sea) on the South (Figure 16). As the water circulates through the whole karst formation and isn't filtered, water pollution can spread over the 2 river basins. The study area being at high altitudes, pollution can impact all areas located at lower altitudes. Agricultural activities, such as manure storage, the systematic use of antibiotics or intensive fattening, can be threats for the quality of water.

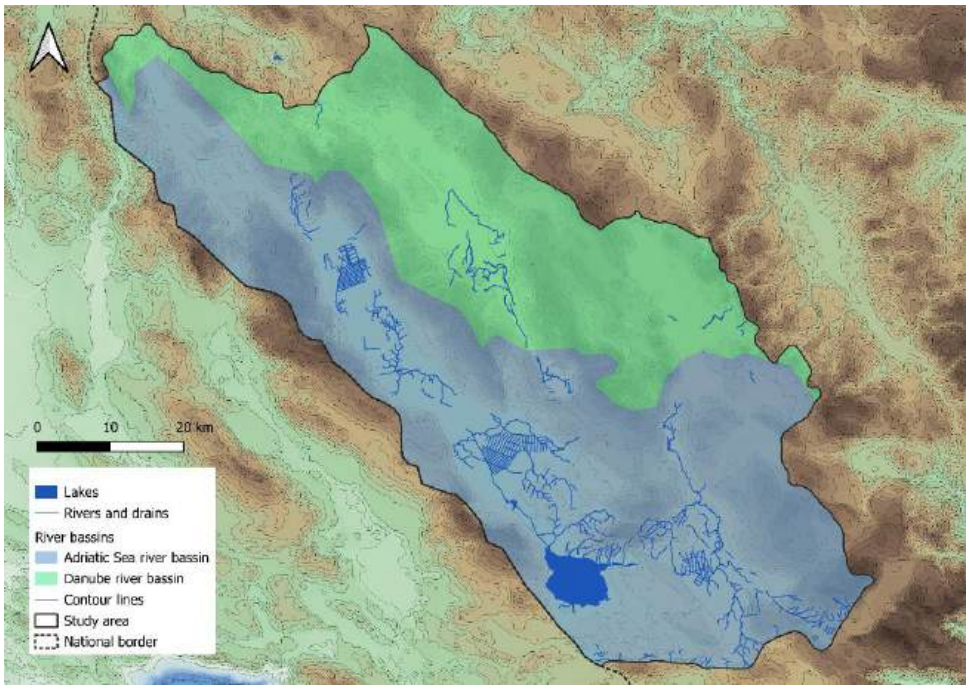


Figure 16: Surface water and river basins of the study area. Realised with QGis, data from the University of Banja Luka.

5. Landscapes units

Local people often refer to the landscape with the words "poljes" and "mountains" ("*planina*" in BHS). However, to have an in-depth analysis of the production systems and their uses of the different areas, we divided it into 4 main landscape units (Figure 17) according to geological criteria, topography and hydrography:

- **Karst polje:** a large (a few kilometres long) and closed depression with a flat bottom and watercourses ending in an underground hydrology network, specific of karst areas (Gilli, 2011), which we split into several sub-units,
- **Karst plateau:** dry areas resulting from a long period of erosion of limestone, characterized by outcropping rocks, lapies, shallow soil, and dolines (Gilli, 2011),
- **Hilly complex:** characterized by slopes of varying steepness, also split into several subunits,
- **And mountain ranges:** areas of high altitude delimited by ridges and steep slopes, more imposing than hilly complexes.

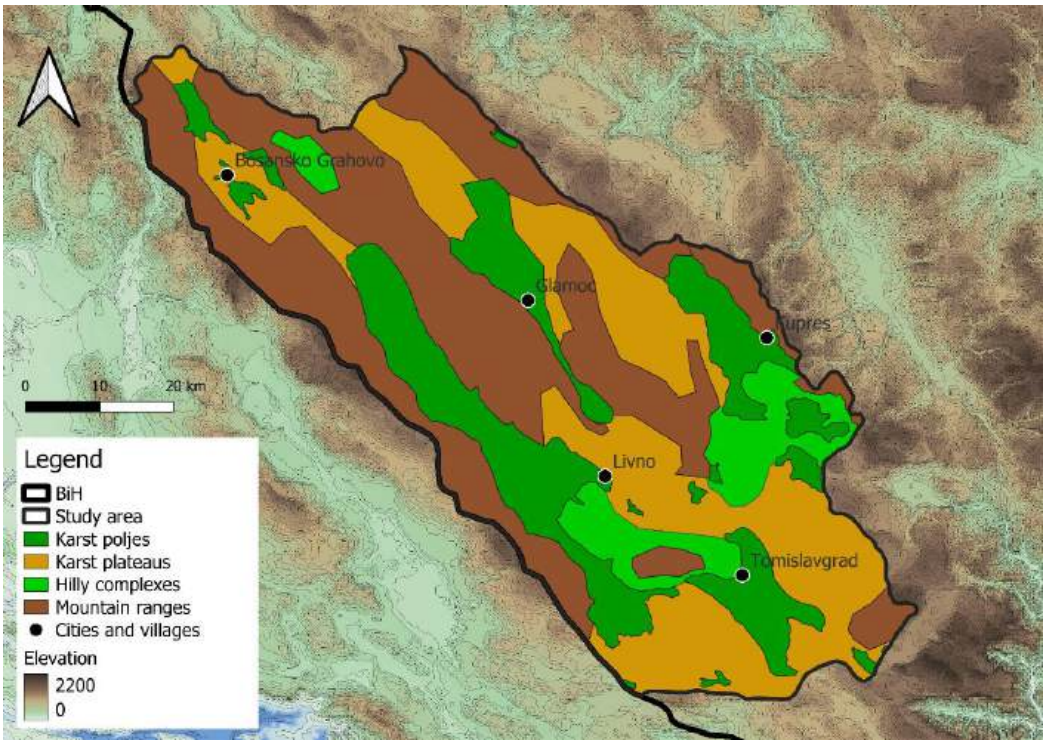


Figure 17: The 4 main landscape units of the study area. Realised with QGis.

5.1. Karst poljes

5.1.1. Different types of karst poljes

Karst poljes can be defined as large depressions in karst formations, where sediments tend to accumulate (Figure 18). Poljes (meaning "field" in BHS) owe their name to this fact: they often are the only large arable land in karst formations – as the surroundings reliefs have shallow soils. They are flat-floored and bordered by at least one steep sloped side (Sackl, 2014). Some of them are entirely closed: streams disappear into carbonate rocks – through ponors – to supply the underground water network. Some others are open poljes, where streams enter or exit them via surface watercourses (Bonacci, 2013). In the study area, most poljes are closed. Only Suićko polje and Duvanjsko polje are open poljes: the water exits Suićko polje through a canyon which flows into Duvanjsko polje.

Figure 18: Glamočko polje - closed polje, flat floor and steep borders. Anouk Fraisse.

Even though their origin remains controversial, karst poljes develop parallel to major structural tectonic trends (such as faults). In the study area, they are elongated in a NW-SE direction which

follows the extension of the Dinarides. They can reach several kilometres in length. Indeed, Livanjsko polje is famous for being the biggest one in Europe: it is 60 km long and 6 km wide, for a total area of 408 km^2. The 3 other large poljes are Glamočko polje (62 km^2), Kupreško polje (82 km^2) and Duvanjsko polje (125 km^2). Many smaller karst poljes are present on the study area. Elevation also varies between the poljes: from 701 m asl to 1206 m asl (Figure 19).

Karst poljes are also characterized by their hydrological regimes. They can be divided into the following groups: (1) permanently flooded or lakes; (2) periodically, partly, or completely flooded; and (3) dry poljes (Bonacci, 2013). In the study area, there are dry poljes and periodically flooded poljes, especially during the wet period (Figure 19).

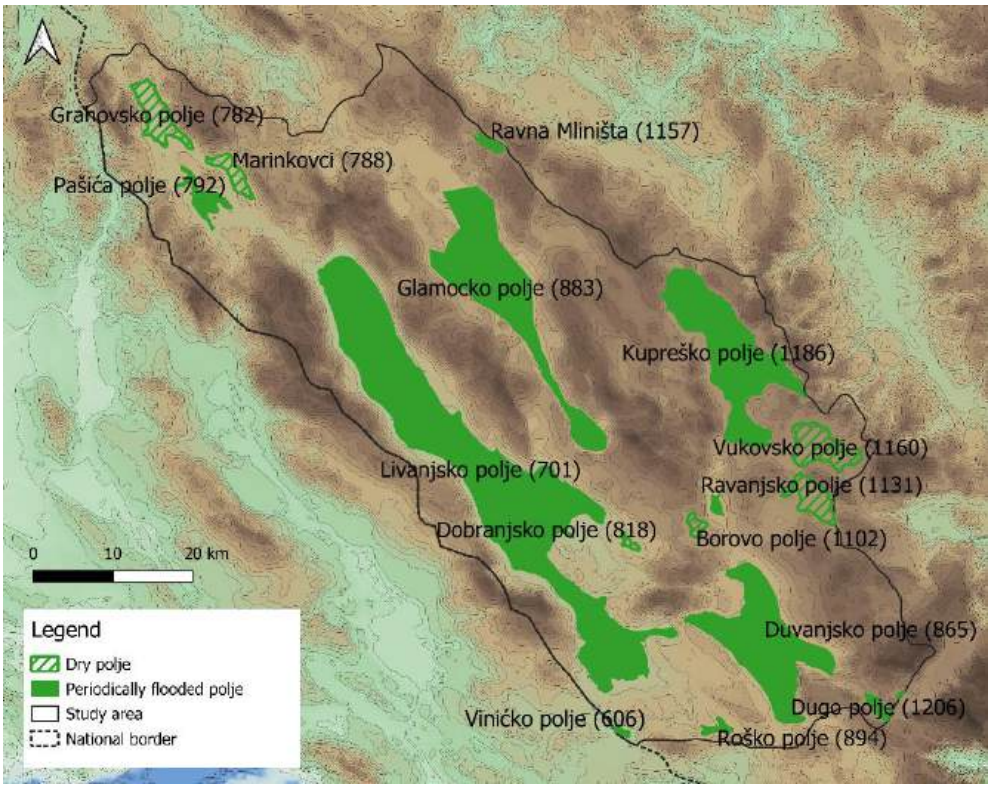


Figure 19: The different types of karst polje in the study area. Realised with QGis.

Occasional elements, such as dolines, are also part of the karst poljes. Jovan Cvijić (a famous geographer from Belgrade, known as the founder of the karst geography) defined hum as a limestone hill that emerges from the flat floor of a polje. It is a residual relief resulting from karstic erosion. Impressive dolines, resulting from the collapse of underground cavities, can be seen at the north of Kupreško polje.

5.1.2. Karst poljes subunits

Each karst polje is divided into 3 subunits: polje bottom, benchland and intermediary zone (Figure 20).

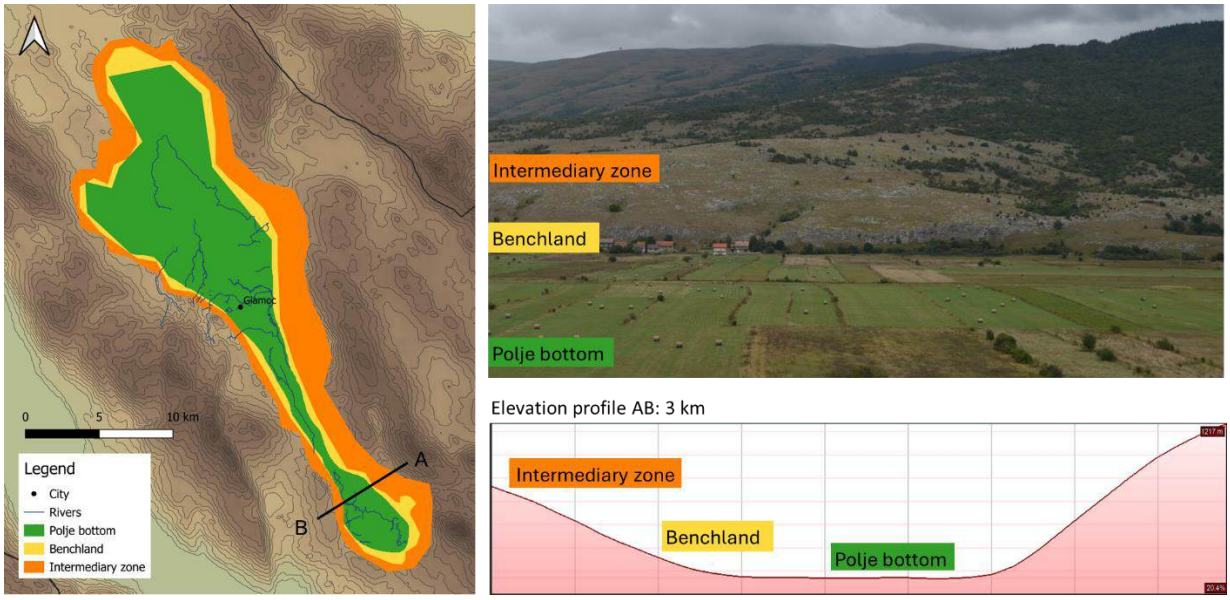


Figure 20: Karst polje subunits, example of Glamočko polje. Realised with QGis.

Polje bottoms

We define **polje bottoms** as flat areas with almost no difference of elevation between two random points (contour lines spaced apart). They are mostly covered with sediments (Figure 13) that can be several metres thick. Most of the surface waterways of the study area are located on the polje bottoms.

They are mainly covered in grasslands, composed of a huge diversity of species: up to 444 in Livanjsko polje (Sackl, 2014). It changes between periodically flooded poljes and dry poljes, and under the influence of the local climates. Dry grasslands mainly grow on the dry poljes but also in areas furthest from waterways in periodically flooded poljes. Wet meadows are more likely to grow on periodically flooded poljes. Moreover, wetlands (recognizable with reeds) form around ponors, lakes and meandering rivers which overflow with precipitations or snow melt. They are characterized by specific fauna and flora. For example, Livanjsko polje harbours 7 plant species endemic to the Balkan peninsula, 1 amphibian species (Olm) and 4 fish species. It is listed as a Wetland of International Importance (RAMSAR), and Important Bird Area (IBA), and is also on the list of potential Natura 2000 sites (Sackl, 2014). The seasonal floodings and surface water highly influence the type of species that can be found on polje bottoms: sometimes, just a few meters are enough to see completely different flowers. However, the water deficit during the hot summer period remains the primary factor for influencing vegetation restoration (Sackl, 2019).

The seasonal floodings impact the agricultural activities: some places aren't accessible early enough during the year for sowing with heavy machinery such as tractors. That is why the draining of some plots was done during the socialist Yugoslavia on polje bottoms. These drained areas are still cultivated today. On the dry areas (on dry poljes or far from the watercourses), arable lands for crop production can be found. However, natural grasslands are often mowed for hay production. As polje bottoms represent the main area of mechanizable grasslands, animals are forbidden in polje bottoms from May until August to ovoid ruining the productions. It means that they must be kept around the farms, in fenced plots or taken to pastures (on intermediary zones or karst plateaus). As the September rains allow grass regrowth, animals are taken to graze these

areas. Some of the wetlands might be used for pasturing, however, when the soil is too wet, it can lead to problems with animal's hooves.

Forests (particularly oak trees) can be observed in the middle of polje bottoms – especially in the largest ones. These zones, far from villages and not easily accessible, tend to be left aside from agricultural uses.

Benchlands

The **benchlands** correspond to gentle slopes of a few meters – or even centimetres – of elevation (Figure 21). They are located in-between the flat bottoms and the slopes that enclose the karst poljes. This is where the water comes out of the rock, via resurgences. The villages are built close to them, as they supply for drinkable water.

The benchlands have different shapes. They can be thin, where street villages are built (as in the middle of Glamočko polje), or wider (as in the north-west of Kupreško polje). In some places, benchlands form small collapsed valleys, where clustered villages are built (as in Dolać in Glamočko polje or Strupnić in Livanjsko polje).

Dry grasslands surround them thanks to the natural water drainage enabled by the gentle slope. They are easily accessible and are less likely to turn into swamps than the polje bottoms, which is an asset for agricultural purposes – especially for ploughing and sowing. Indeed, most of the benchland are used for growing grains. As for polje bottoms, animals are forbidden on benchlands from May until the end of the harvest (in August). Outcropping rocks can appear on the benchlands, especially on dry poljes or in the dry areas of flooded poljes. Impressive stone removal sites were observed in these areas (Figure 21). In the most extreme cases, they can make mechanization impossible.

Figure 21: Benchlands of karst poljes. On the left, Dobranjsko polje. On the right, stacks of stones on Marinkovći polje. Anouk Fraisse.

Intermediary zones

Right above the benchlands is a slope discontinuity of varying steepness which closes the karst polje, the **intermediary zone**. It can be abrupt and lead to mountain ranges or gentle and turn into karst plateaus and hilly complexes. In Kupreško polje, the intermediary zone is rather smooth: it slowly turns into a karst plateau. In Livanjsko polje or in the southern part of Glamočko polje, the intermediary zone is abrupt and forms very a steep slope.

On these areas, the soil is much thinner than in the polje bottoms or the benchlands. Indeed, the steep slope prevents from sediment accumulation and favours erosion. Intermediary zones have many outcropping rocks. As there is almost no soil, water infiltrates directly in the rock. The whole hydrography network of these areas takes the form of an underground network. There isn't any surface waterway. Only very few sources were observed.

On the South-West side of the poljes, where the sun hits, the vegetation forms grasslands. At the lowest altitudes, and under the influence of the Adriatic Sea climate (Figure 8), they are mostly dry grasslands. Around Livanjsko polje for example, some aromatic plants grow. On the other hand, Kupres is located higher in altitude and is more under the continental climate influence – as well as on a dolomite substrate. It is not as much impacted by the hot summer temperatures as Livno or Tomislavgrad. Dolomite is also less porous than limestone and the soil is thicker, which favours water retention. All these elements make the grasses to stay green longer. On the North-East side of the poljes, where the sun hits less, forests grow (oak trees, walnut trees and rosehip were observed). The steepness of the slopes along with the outcropping rocks make them impossible to be mechanized. However, intermediary zones can be used as pasture areas.

5.2. Karst plateau

Karst plateaus result from a long period of erosion of limestones and to a fewer extent, dolomites. They are due to water infiltration and dissolution of carbonates rocks, which form various shapes of various sizes such as dolines. They represent wide areas of shallow soils (erosion is faster than soil formation) and outcropping rocks. Alike intermediary zones, water infiltrates directly in the rock. Karst plateaus are thus characterized by their underground hydrology network.

Dolines are closed depressions, mostly shaped in circles, of varying sizes – a few meters wide (Figure 22). They can form through the dissolution of the carbonate rocks (the carbonates elements leak while the clay stays on the surface). They can also appear when the roof of underground cavities collapses. In both cases, they collect rainwater and form natural tunnels connected to the underground water network. The bottom of the dolines is filled with accumulated sediments (and clay), of varying thickness (Gilli, 2011). Sometimes, the accumulation of rainwater above these sediments creates a waterproof surface and lead to the formation of natural water ponds. These ponds can be used by animals, whether they are domestic or wild ones. They constitute the only arable land in the middle baren land, composed of shallow soil and outcropping rocks (Gilli, 2011). The occurrence of dolines varies from one karst plateau to the other. On Brišnik, above Tomislavgrad, there are a few dolines. On Hrbina (in-between Glamočko polje and Kupreško polje), dolines are all over the place (Figure 23).

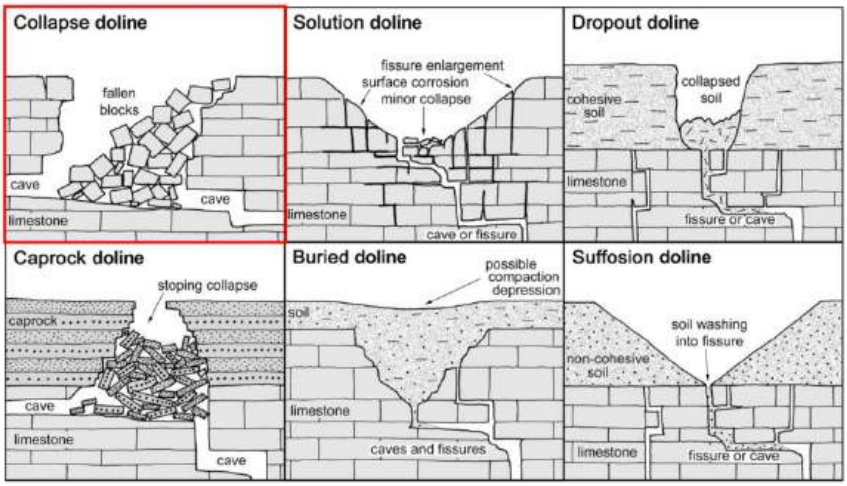


Figure 22: The different types of dolines (Kaufmann & Sauter, 2013).

The vegetation on karst plateaus is low, with punctual small trees and is called calcareous grasslands. They are associated with thin basic soil, such as that on limestone. Plants are typically short and hardy (as it is a dry area). Again, the closer the karst plateau is from the Adriatic Sea, the

richer it gets in aromatic plants that grow under Mediterranean – or Adriatic – climate. The elevation also plays a role in the species that grow on the karst plateaus.

These grasslands are maintained by animals grazing, usually sheep and sometimes cattle. Indeed, karst plateaus can be used as summer pastures. The nature of the soil – karst formation composed of limestone – makes the summer rains insufficient to enable the grass to stay green; it turns dry during August. Moreover, as only a few farmers use these areas, animal pressure is not enough to compact the soil in the dolines to make water available until the end of the summer. The animals are going down before end of summer, to graze in the karst poljes, were the grass stays green a little longer. Mechanization remains impossible due to shallow soil and outcropping rocks, only very wide dolines could be mechanized. Changes is the vegetation is observed in the most remote karst plateaus; they slowly turn into forests.

"The grass quality is less good than before because of the fewer animals grazing, unwanted species are more and more growing... shrubs are more and more present" (H-Gla-05).

Figure 23: Karst plateaus. On the left, Hrbina. Hrustan Kadić. On the right, Krug planina. Anouk Fraisse.

5.3. Hilly complex

Hilly complexes correspond to a geological unit of lacustrine facies: deposits that are formed by geological processes in lakes. They are composed of clay, marl, limestone interbedded with brownish coal. It is indeed, in this area, that coal mines can be found – for example, nearby Tužnića in Livno. They present fewer outcropping rocks and thicker soils than karst plateaus, due to their geological origin. They are small but complex areas. We thus decided to divide them into subunits:

- **Small plains**: relatively flat areas formed by alluvial deposits, that can be flooded when rivers overflow,
- **Foothills**: gentle slopes where villages are located, allowing natural water drainage,
- **And slopes**: ending in hilltops, characterized by their steepness and higher elevation.

Their organization is quite similar with the one of the poljes. The small plains are covered in majority by wet meadows, wetlands forms around waterways and lakes. The foothills are dryer areas (just as the benchlands), thanks to the gentle slope. Dry grasslands grow on these areas. Slopes are above the foothills and can be described the same way as the intermediary zone of the poljes. As the soil is thicker in the hilly complex, there is more water retention. Aromatic plants are less likely to grow here than on the intermediary zones. Indeed, the vegetation is less short and hardy; it grows a bit taller and stays green for a longer period. Forests largely occupy the slopes – numerous hazelnut trees as well as oak trees were observed.

Mechanization can occur in the small valleys with the same constraints as for the polje bottoms around wetlands and swamps. Foothills are also arable lands, with the advantage of not being flooded or wet. Most of the time, slopes are too steep for using tractors but can be valorised through pastures.

5.4. Mountain range

Mountain ranges are oriented from North-West to South-East, following the orientation of the tectonic movements that led to the formation of the Dinaric Alps. They are characterized by their altitude and their steep slopes. They encompass ridges and peaks: Cincar, Malovan, Konj, Veliki Šator are of the most famous ones. They are located between poljes and above karst plateaus or hilly complexes. On the Southwest, the Dinara (which gave its name to the Dinarides) and Kamešnica mountains mark the limit of the national border between Croatia and BiH. Staretina and Velika Goljia mountains separate Glamočko polje from Livanjsko polje. Tušnica is the limit between the municipality of Tomislavgrad and Livno. Vran mountain, on the South, is the border with the neighbouring canton. Kujaća mountain is located between Glamočko polje and Kupreško polje. And on the North-East, the Raduša mountain delimits the border between FbiH and RS.

Figure 24: Mountain ranges. On the left, Šator. On the right, Cincar. Anouk Fraisse.

Most of the mountain ranges of the study area are covered with multi-specie and multi-age forests. They are composed of various deciduous and thorny trees (managed by the Šumaria). However, some areas are too rocky, above the tree limit or too exposed to strong winds – as the Bura – for the forest to grow. Their substrate is made of carbonates rocks through which the water infiltrates, as in the rest of the karst formation. As the soil is thin, water isn't retained, and dry grassland grow (Figure 24). They also grow on the North-West side of some of the poljes, where the sun hits. Many junipers were present on these areas.
On the mountain ranges that are the closest to Croatia, the Adriatic Sea moderates the temperatures (Figure 8) and aromatic plants grow quite high in altitude. On the mountains that are more inland, the local climate is colder and such plants cannot grow.

6. Summary

The different landscape units along with their characteristics and potential agricultural uses are summarized in Table 1. To clarify which units are used for what and by whom, we chose to represent the landscape units as on *Figure 25*. It will be used in the description of the farms. As hilly complexes work the same as karst poljes and karst plateaus, we chose not to represent them on the figures.

Table 1: Summary on landscape units. Anouk Fraisse & Emmanuel Artus.

LANDSCAPE UNITS	SUBUNITS	CHARACTERISTICS	VEGETATION	AGRICULTURAL OPPORTUNITIES/THREATS
KARST POLJE (depression of several kilometres, bordered by at least one steep slope, with surface waterways) ***Vary in size, elevation, water regime and vegetation***	**Polje bottom**	Flat area, thick soil, periodically flooded or dry, rivers and lakes	Wet meadows, wetlands, dry grasslands, forests (oak trees)	Pastures, hay, arable land, drained arable lands, mechanization can be difficult due to muddy areas
	Benchland	Gentle slope (a few centimetres to a few meters), natural drainage, few outcropping rocks, resurgence, villages	Dry grasslands	Arable land, hay, pastures
	Intermediary zone	Steep slopes, shallow soil, water infiltration, very few springs	Dry grasslands, forest (oak trees)	Pasture, mechanization impossible due to steep slope and outcropping rocks Forestry
KARST PLATEAU (formation due to the erosion of rocks with underground water network)	Shallow soils, outcropping rocks, lapiés, dolines, no surface water (only underground network)		Calcareous grasslands	Pastures, mechanization impossible due to shallow soil and outcropping rocks
HILLY COMPLEX (formation due to deposits in lakes, thick soils, surface waterways)	**Small plain**	Relatively flat area, thick soil due to alluvial deposits, rivers and lakes	Wetlands, wet meadows	Pastures, hay, arable land, mechanization can be difficult due to muddy areas around rivers
	Foothill	Gentle slope (a few centimetres to a few meters), natural drainage, resurgence, villages	Dry grasslands	Arable land, hay, pastures
	Slope	Steep slopes, rather thick soil, small water retention and water infiltration	Grasslands, forests	Pasture, mechanization impossible due to steep slope Forestry
MOUNTAINS RANGES (steep slopes in high altitude, above 1500 m asl)	Steep slopes, high altitude (above 1500 m asl), peaks and ridges		Forests, dry grasslands	Pastures Forestry

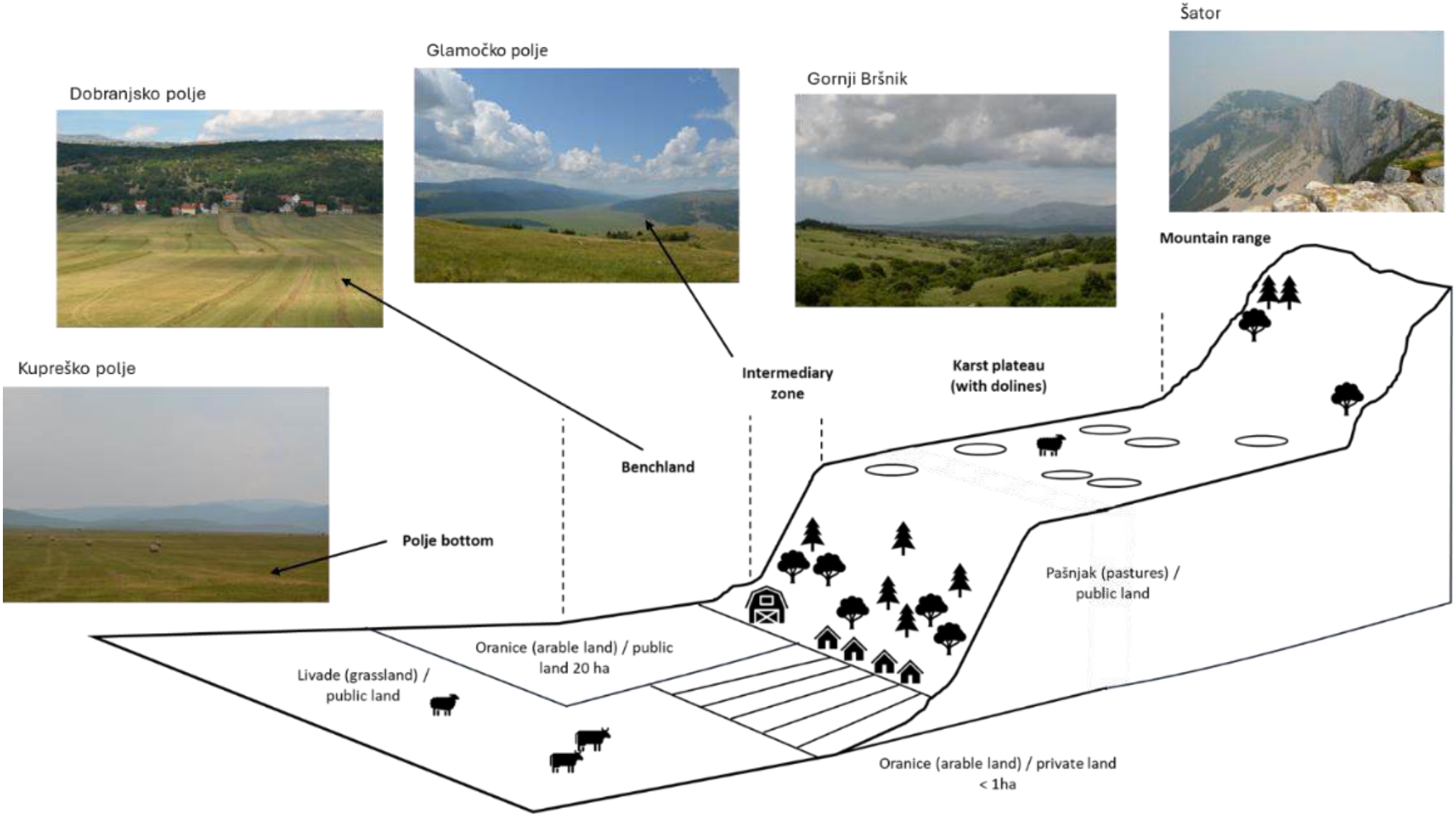


Figure 25: Presentation of the landscape units. Emmanuel Artus & Anouk Fraisse.

Part III: Agrarian history

As our methodology is based on semi-directives interviews to question stakeholders' memories, we focus on agrarian history after 1970. For the previous periods, we mainly relied on scientific literature.

1. Before the 70's, different political regimes setting agricultural conditions

For several centuries, BiH has been at the demarcation between Turkish, Western European and Eastern European influences. BiH has been part of the Ottoman Empire (1463-1878), the Austria-Hungarian empire (1878-1918), the Kingdom of Yugoslavia (1918-1939), and the socialist Yugoslavia from 1945 to its independence in 1992.

For long times, nomads (Vlachs/Aromanians) and peasants coexisted in the study area. Nomad populations were coming for summer grazing, from more inland areas. Their routes were deep in the mountains (Dinara, Hrbina) while local peasants used grazable areas closer from their villages. Starting with Ottoman controls and taxes on livestock, and to avoid them, nomads were joined by the peasants doing transhumance deeper in the mountains. Anyway, livestock breeding was already an important activity.

After the defeat of the Ottoman empire in BiH, Austro-Hungarian (1878-1918) established policies favouring cattle and horse breeding. In Livno, focus was done on milk production and cheese making. An agricultural station was built in Livno in 1886. Renowned cheese makers from Europe came as teachers and researchers. Recipes such as Roquefort or Feta were piloted with local milk production and commodities. In 1900, the Gruyere recipe was assessed and adopted. It was adapted to the local context and became the recipe of the well-known *Livanjski sir*, processed at the state station school and in households (Bernardoni & Estève, 2008).

The Austro-Hungarian empire also encouraged modernisation. Cooperatives (farmer associations) were created for obtaining loans. In Kupres, resistant and productive breed selection was promoted through cattle exhibitions (Figure 26).

Figure 26: Exhibitions encouraging cattle selection, 1900. Source: Bosnian messenger in (Ivić, 2019).

From 1914 to the 1950's, due to the destruction brought by the two World Wars, "livestock was not produced exclusively and directly for the market, but only the surplus was sold" (Ivić, 2019). The fights between Partisans and *Ustaše* during WWII left the study area devastated (Figure 27). "In Kupres, Glamoč and Livno [...], due to the large loss of livestock [up to 80%], there was a lack of traction power for cultivating the land and fertilizing" (Ivić, 2019). By then, most of the farms consisted of households with less than 20 sheep. Animals from the selection process which occurred the previous decades almost completely disappeared.

Figure 27: mass grave commemorating people killed by Ustaše, Donje Vukovsko. Anouk Fraisse.

The Socialist Yugoslavia was formed right after WWII. Until the early 50's, it realized a strict Stalinist model of agrarian reform. Lands were confiscated. It mostly affected the biggest landowners, who had to reduce their herds. In fact, before having confiscated all the lands, Yugoslavia turned back on Stalinist model and allowed inhabitants to have some hectares of arable land and a few heads of cattle. A maximum number of hectares per household was set, making it difficult for an average household to have more than 5 cows and 20 sheep. The confiscated lands were used in State farms. In our study area, it represented about 25% of the total arable lands and more than 75% of the pastures, split between four State farms – in Kupres, Glamoč, Livno and Tomislavgrad (Annex 6). Nevertheless, all the pastures remained freely accessible for private farmers. It enabled some families to have up to 100 sheep. After the 70's, it got even easier to widen private farms – as well as other private operations. Indeed, privates could overtake the maximal allowed hectares of land if they paid for extra-taxes.

Yugoslavia was also a main actor for the mechanization process. It was first implemented in the State farms, then followed by private farms. Only a small number of families (usually one per village) could afford equipment as tractors, which was rented or borrowed by the other families. To promote mechanization, the state created *Poljoprivredno zadrugas Tomislavgrad* (Agricultural cooperative Tomislavgrad), a public-owned company for selling agricultural equipment, with one selling site in Tomislavgrad and another one in Glamoč. Tractor from *Industrija Mašina i Traktora* (IMT, a Yugoslav brand, Figure 28) progressively replaced the bulls and horses used for work. Those horses were freed and are now the ''Livno wild horses'', the main touristic attraction of the area (Figure 28). Cows were then only used for milk and meat production. The traditional and rustic Buša cow was replaced by Western European breeds, such as Simmental (Figure 28).

Figure 28: From left to right, (1) Oranje s volomi i ostanom, Mato Kaić; (2) Horses carrying hay in the late 60's, picture from Cafe Brišnik, Tomislavgrad, unknown; (3) Tractor IMT, Anouk Fraisse; (4) Simmental cow, Anouk Fraisse. (5) Wild horse, Anouk Fraisse.

"It was mostly the Simmental and Montafon breeds, from the western European countries" (H-Kup-05).

During the 20th century, tourism developed, and Dalmatia became the most touristic spots of Yugoslavia. Bosnian farmers obtained better prices there than in local marketplaces. Sea products and wine were brought from the coast while wool, cheese (*Livanjski sir, Vlašićki sir*), and manure were sold there. The whole Canton 10 was then known for its pastoral areas, livestock production and cheese-making (Annex 7).

2. 1970 – 1992: cohabitation of state-owned and private units

2.1. Populations and economic context

Until the 70's, population in the study area remained stable. However, the population in cities increased thanks to non-agricultural jobs (Figure 29): State farms but also industries for steel, wool or textile, food processing industries, transportation companies (especially the Livno bus company), coal mines or forestry companies (*Šumaria*, wood processing), ... Incentives for workers to move in cities were made: *"Livno industries had special accommodation plans for good workers"* (H-Liv-03). Some people also went to further areas within Yugoslavia, especially for agricultural seasonal jobs in Vojvodina. For example, there were many women from the study area who were employed for harvesting potatoes (Figure 30). At that time, Yugoslavia growth index was the third highest in the world. In parallel, during the Cold War, Egypt and India – the two other non-aligned countries – and Middle East countries attracted qualified and unqualified Yugoslav workforce (Carmichael, 2015). "*They were mainly men, leaving without their families for several months, sometimes years"* (H-Liv-03). Indeed, Yugoslavia had good relationships with historically linked countries: western Europe (especially Germany and Austria) due to the Austro-Hungarian presence until WWI, as well as Turkey and other formers countries of the Ottoman Empire.

During this period, agriculture was not the only income of most of the households – whereas it was the case before WWII. As men went to work in cities or foreign countries, women and children who usually stayed on the farms kept fewer animals.

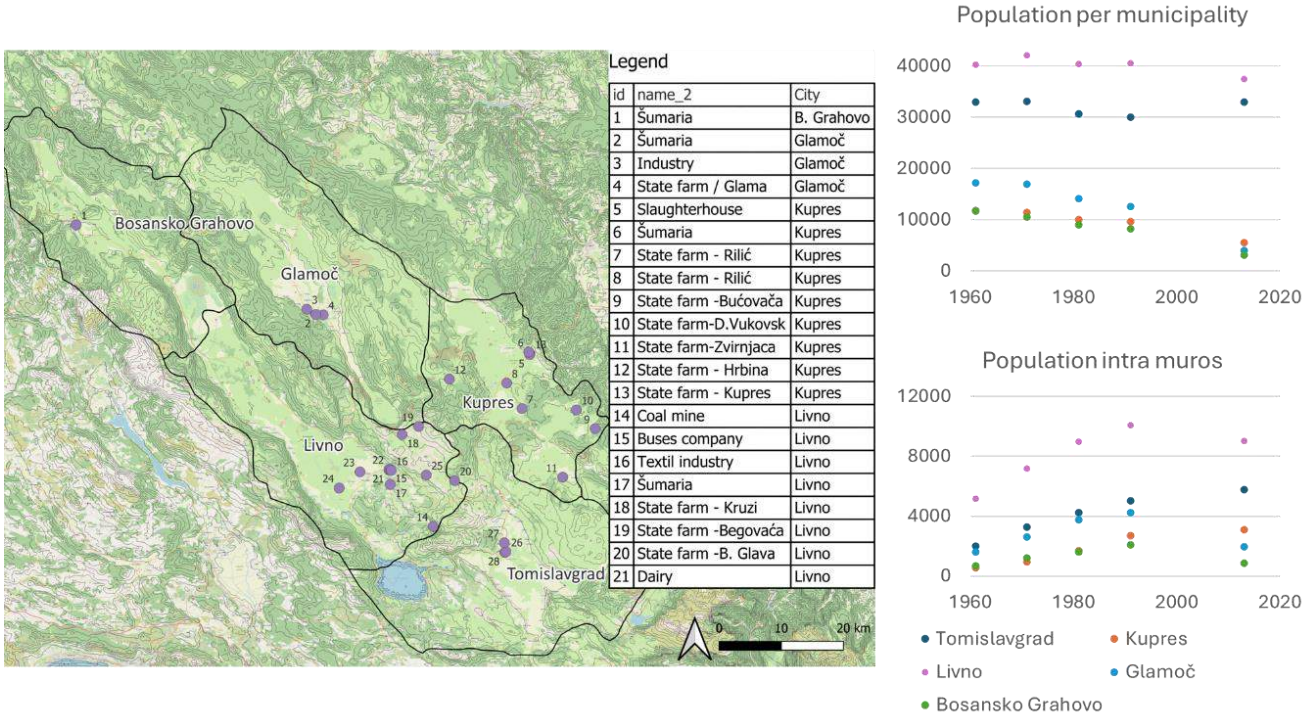


Figure 29: On the left, main employers during Yugoslavia. QGis, data from interviews and bibliography. On the right, population per municipality and per city. Data from Wikipedia, census from 1961, 1971, 1981 and 1991. Emmanuel Artus and Anouk Fraisse.

Figure 30: Women harvesting potatoes in Vojvodina, late 60's. From Brisnik Cafe, Tomislavgrad, unknown.

After the 70's, the Yugoslav economy declined, and the state eased people definitive movement toward Western Europe. Urban population rose slower, while cantonal population slightly decreased (Figure 29). In the countryside, the number of workers decreased. At the same time, mechanization started to appear in private farms. The remaining farmers abandoned the remotest lands, crops and hay were done down in the poljes closer to the villages. Those lands were more suitable for tractors. Manual hay production, which was the only production on the public lands of karst plateaus and mountains also came closer to the villages. The muddiest zones of polje bottoms, only suitable to mowing hay by hand, were left aside. Herd movement towards mountain pastures, such as on the Dinara, decreased.

"When I was kid, in the late 60's, those lands were mowed. My grandparents even had summer accommodation up in the mountains, a few hours of walk from here." (H-Kup-03)

2.2. Private farms on private arable lands

The following farms used private lands for growing crops and mowing part of their hay. For pasturing, they relied on public lands also used by State farms.

2.2.1. Side farming in households

In this period, most farms were households keeping animals and having a job aside (in the cities of the study area or in foreign countries, as Germany). They kept a few Simmentals or Montafone cows and between 10 and 20 Pramenka sheep. Farmers sold calves between 3 and 4 months. The milking of the cows started right after it and was done by hand. Cow's milk was brought in buckets on the closest road, and then collected to be processed in the dairies of Livno or Kupres. The lambs were also sold about 4 or 5 months old. The ewes were milked, but all the milk collected was drunk or processed by the family. Calves and lambs were sold locally and in Dalmatia.

On the benchland was a rotation between hay and crops on farmers' private lands. Hay was the only production on the polje bottom. All over the year, animals slept in stables – usually the ground floor of the house. During wintertime, they were given hay and cereals. In summertime, they were daily brought to pastures. Between May and August, it was forbidden to enter the polje with animals so to ensure crop and hay production. People walked some kilometres with the animals on intermediary zones and karst plateaus. People from one village traditionally gathered their animals in the same flock. Every family looked after the animals for a few days in a row, depending on the number of animals they had. Cows and sheep were kept on two different flocks. After mowing and harvesting crops, animals could graze the polje without surveillance (Figure 31).

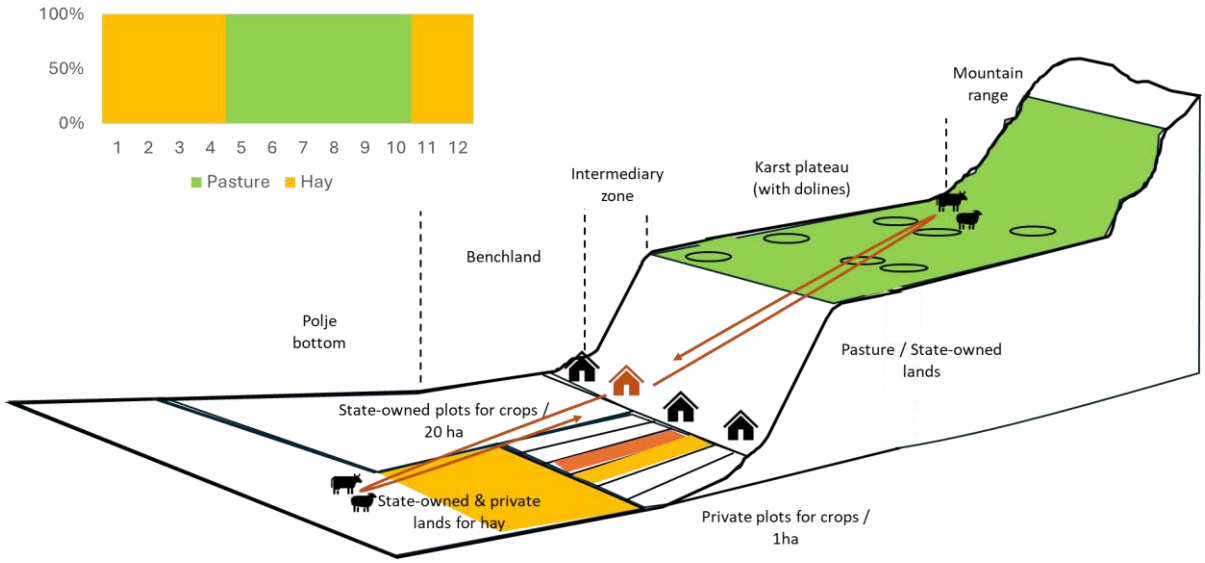


Figure 31: Side farming spatial organization and animal feeding calendar (in % of dry matter (DM)). Emmanuel Artus and Anouk Fraisse.

The main constraint for increasing herds was the quantity of hay collected. Mowing time was the most labour-intensive period of the year – from June to early August, depending on the local climate. Between 1970 and 1990, mowing was more and more done with tractors. At the end of the 1990, almost every family had a tractor with mowing equipment (Figure 32). Ploughing and tilling were also handled with tractors. Before November, about 1 ha of wheat was sown. Early spring was the time for sowing about 1 ha of barley. Wheat and barley were rotating with 3 years of grassland, growing naturally. The first year was not mowed, not to weaken the young plants.

Figure 32: Tractor and mowing equipment present on side farming. Anouk Fraisse.

2.2.2. Traditional transhumant systems for cheeses and meat production

The same breeds (Simmental for cows, Pramenka for sheep) were raised by cheese makers. As their whole family was only dedicated to agriculture, they had more animals than side farmers: about 200 sheep and 15 cows. Even if their key production was cheese, a large part of their income came from meat. Lambs and calves were sold for meat about 4 months old, around May, just before leaving for summer pastures. Most of the products were sold in Dalmatia. Indeed, after Belgrade, the Adriatic coast was the main touristic destination during the Yugoslav period (Sallnow, 1985). Foreign tourism was from "the comfortable but careful middle classes" (Walton, 2010), coexisting with domestic workers on holydays. Cheeses used to be sold to restaurants and hotels, with a constant look at the quality of the products, to obtain the best prices.

"I sold it in one of the best hotels of Split! Not everyone could do that!" (H-Liv-05).

Every year on benchlands, farmers sowed about 10 ha of wheat and barley. Barley was sowed in spring. Socialist government taxed households possessing more than 10 hectares. As for side farmers, this rotation included these crops and natural grasslands but cheese making farms had to pay taxes. Hay was also produced on the polje bottom. During wintertime, animals are kept in

stables and fed with hay and cereals from the farm. From May - and the grass development - to August, the animals were taken to the pastures on karst plateaus, a few days of walk away. Due to the quantity of animals, herds were taken further away than the ones of side farms and temporary accommodations were set on the pastures. It could have been a tent, a caravan, or even a *katun* (small wooden house). Up there, ewes and cows were milked and cheeses processed. After mowing and the first summer rains in August, when some more grass was available, animals could freely pasture the polje bottom until the first snow (Figure 33).

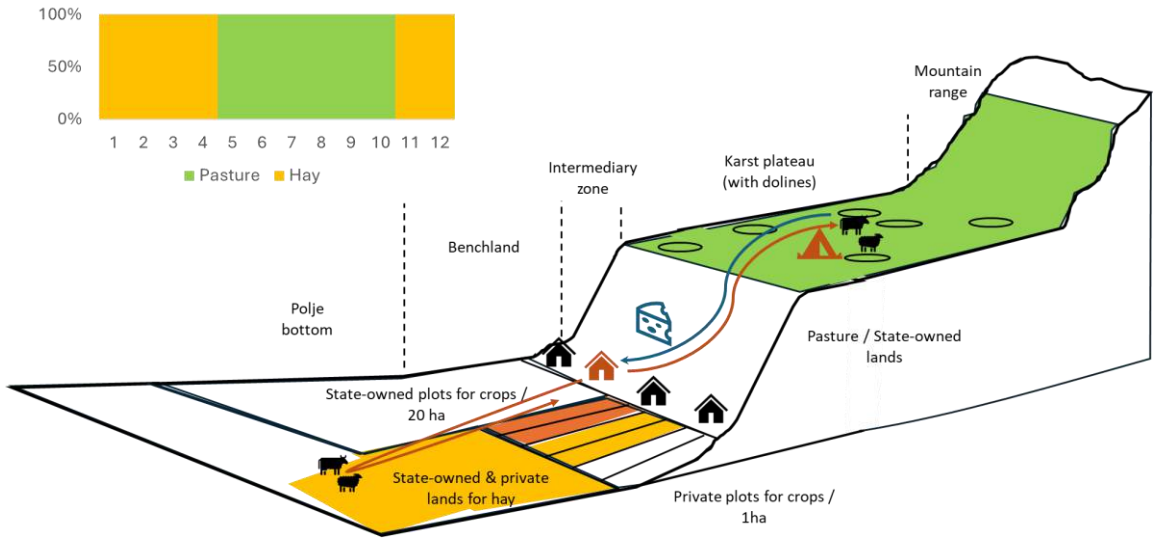


Figure 33: Cheese making farms spatial organization and animals feeding calendar (in % of DM). Emmanuel Artus and Anouk Fraisse.

Because of the small size of the plots (about 1 ha), it was useless to have large machineries: these farms had the same equipment as side farms (Figure 32). However, they had several tractors for managing more work at the same time. They also had milking buckets for the cow (the milking of the ewes was done by hand). They got equipped just after the State farms, in the early 70's. Mowing was also the most labour-intensive period of the year and required all family members to work (meaning around 10 person as the families were big back then). If the quantity of hay was not sufficient, sheep were shepherded in the polje in wintertime to spare feed.

The types of pastures determined the kind of cheeses that was produced. Where aromatic herbs were predominant on pasture lands, hard-type cheeses were made. Those places are the closest to the Adriatic Sea and its climate influence (Figure 5). Livno cheese producers used to go "*In Korićina… between Glamoč and Livno, [where] there are more than 128 herbs species*" (H-Liv-05). On the northern parts, dairy production was more focused on *kajmak* (a fresh cheese). Sheep cheese was only produced during summertime, while cow cheese was made all year round.

2.2.3. Traditional nomadic systems for meat and cheese production

Transhumant shepherds (referred to as "nomads" in BHS) are farmers doing winter and summer transhumance. They don't answer to the classic definition of nomads because they have a permanent accommodation for some periods of the year.

One transhumance route was from Dalmatia to Dinara (6 and 7 on Figure 34). Those farmers didn't need winter transhumance as there was enough grass in Dalmatia for wintertime.

Nomadic shepherds from Travnik made their winter transhumance towards Vojvodina (in the current Serbia) and even as far as Slovenia, in huge areas specialized in crop production. Animals grazed the aftercrops and grains that had fallen on the floor during harvesting. Transportation was done by train or truck. They would go to Travnik for some time in spring. Starting in May, they went

to Hrbina, for summer pastures. They needed 4 days to reach the place. About August, when water wasn't available anymore in Hrbina, they would go down to Glamočko or Kupreško polje, and then back to Travnik (1 to 5 on Figure 34).

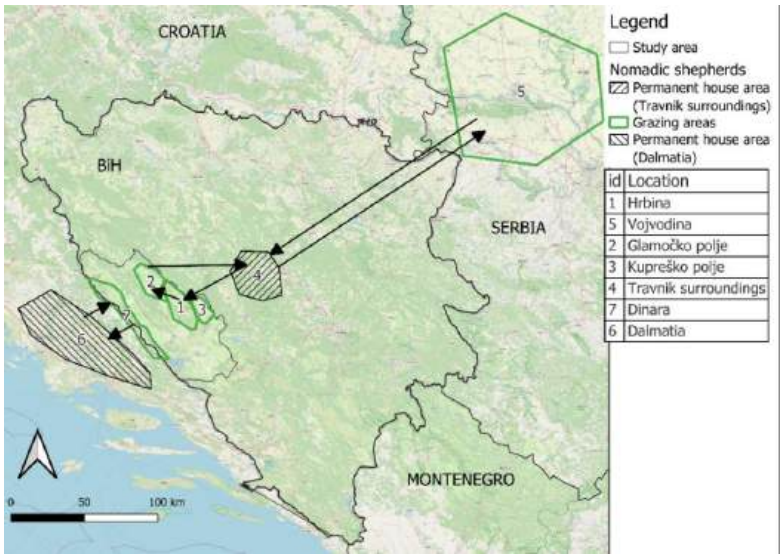


Figure 34: Transhumance routes of nomadic shepherds over one year. QGis. Emmanuel Artus and Anouk Fraisse.

This system had *Travnička Pramenka* sheep and Simmental cows. It relied on familial organization. A part of the family was moving the sheep to the different pasture locations while the other stayed in Travnik, where around 15 cows stayed all year long. Moreover, family members were needed for mowing hay and harvesting grains there. It was used as animal feeding for cows and sheep (35). Nomadic systems also relied on an inter-familial organization. Between 3 and 5 families gathered their animals in one larger flock for transhumance. It was about 1000 sheep in total, as each family had 200 to 250 adult sheep.

"Here, on Hrbina, were about 50 families in 1970!" (H-Gla-05).

Figure 35: Nomadic systems – Feeding of cows (left) and feeding of sheep (right). Emmanuel Artus and Anouk Fraisse.

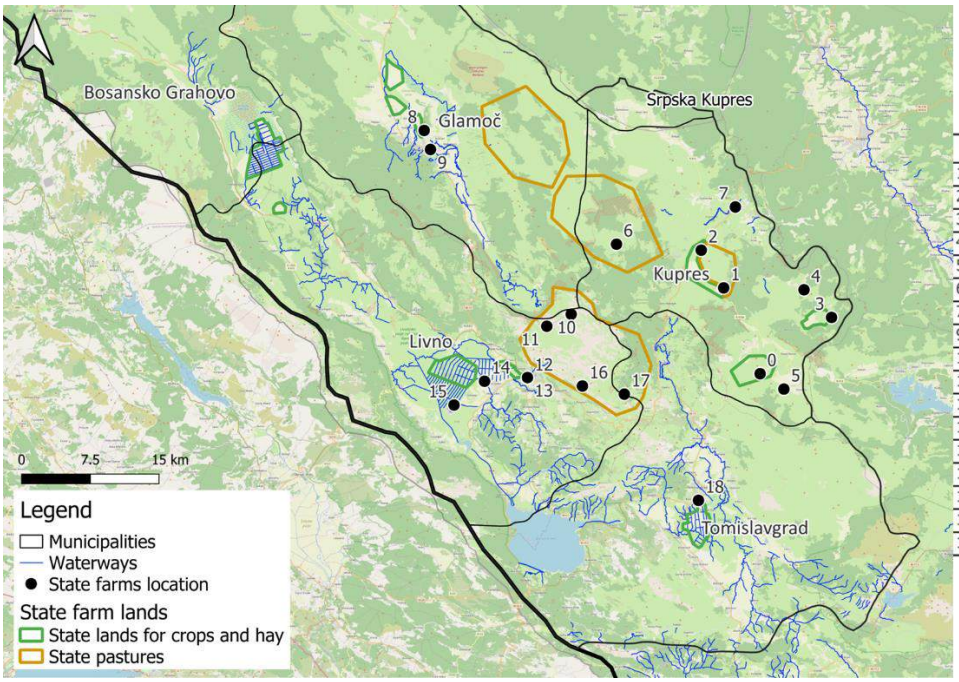
Those systems also sold both cheese and meat. Pramenka naturally give birth around January. Lambs were raised for a few months on winter pastures and most of them were sold around Travnik in spring, before going to summer pastures. There, the ewes without lamb were milked (by hand) and their milk was processed into Vlašićki cheese, using lamb skin (Figure 36). Those cheeses were mostly sold on the coast (Dalmatia, Istria) to tourists.

Figure 36: Lamb skins in which cheeses are produced. Anouk Fraisse.

2.3. State farms on state-owned lands in the study area

2.3.1. Common organization

There were four State farms on the study area, in Livno, Tomislavgrad, Glamoč and Kupres (Figure 37). The operations of each farm were split in several locations over each municipality. Some State farms also processed some of their own products: milk processing in Livno, meat processing via slaughterhouses in Kupres and potatoes processing in Glamoč. Along with the State farms processing units, there was one state-owned dairy in Kupres. The State farms were the main agricultural producers of the area. For example, half of the 40 000 sheep present on Kupres municipality belonged to the State farm. They were also one of the main employers.



	Municipality	Location
1	Kupres	Rilić
2	Kupres	Rilić
3	Kupres	Bućovača
4	Kupres	D.Vukovsko
5	Kupres	Zvirnjaca
6	Kupres	Hrbina
7	Kupres	Kupres
9	Glamoč	Glama
11	Livno	Kruzi
10	Livno	Begovaća
17	Livno	Borova Glava
12	Livno	Dairy
13	Livno	Crop production
14	Livno	Guber
15	Livno	Grborezi
16	Livno	Prizina
18	Tomislavg.	Tomislavgrad

Figure 37: State farms spatial organization in the study area. Interviews and observations. QGis. Emmanuel Artus and Anouk Fraisse.

The confiscated arable lands were exclusively used by State farms. Those lands were the flattest from the area. Located in the polje bottom, they were drained with stemmed canals around the plots for limiting floods and ensuring production. Their large size (~20ha per plot, when private lands were less than 1ha) was made for the newest machineries. State farms' capitals were the highest over the study area. Tractors (up to 220 HP), crops and hay equipment were larger than private farms, cow milking machines were quickly installed. They were also the first one to get equipped with silage harvesters. They grew feed for animals, only the State farm of Glamoč growing potatoes for human consumption. Except Tomislavgrad State farm, all the State farms used the karst plateaus for summer grazing (Figure 38). Barns and accommodations for workers were set up in the pastures: in *Krug* (the karst plateau under the Cincar) for Livno operation, and in *Hrbina* (the karst plateaus between Kupres and Glamoč) for Kupres and Glamoč operation. Those pasture lands were under the state jurisdiction but were shared with private farmers.

Each State farm was independent and competed against each other. For example, Kupres and Livno dairies competed for the same cow's milk suppliers. A state-owned company was even in charge of the milk collection of private farmers in Tomislavgrad. It first supplied the Kupres dairy, changing for the Livno dairy in 1985.

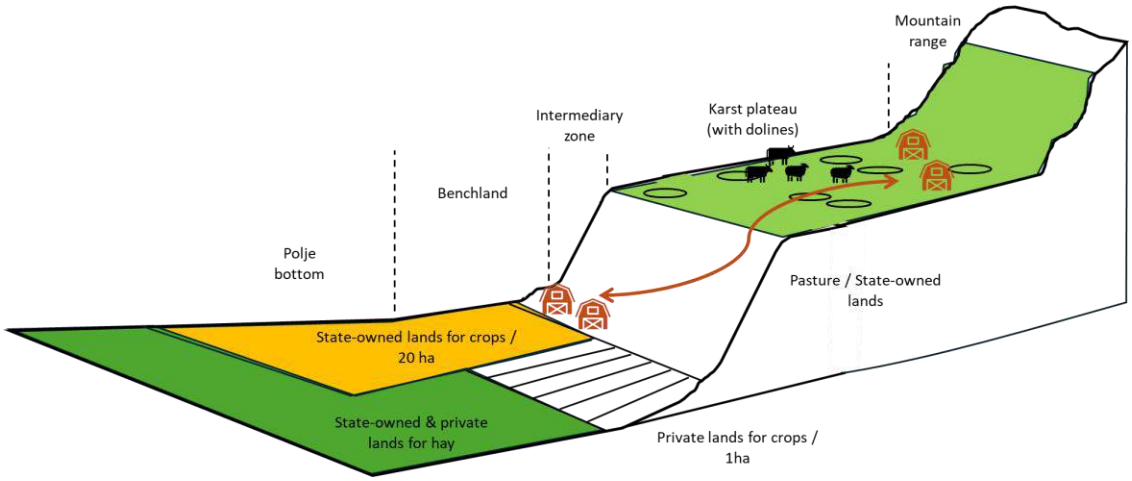


Figure 38: State farms spatial organization and use of the landscape units. Emmanuel Artus and Anouk Fraisse.

2.3.2. Livno State farm for cheese production

Named *Anto Zoro Kelava* from 1945 to 1950, Livno State farm was then called *Poljoprivredno dobro Livno* (Livno agricultural farm). Its main productions were cheeses, lamb and pig meat, and cereals (Figure 40). Each production was overseen on a different location and managed by one person. In total, there were 450 employees.

In the building from the former Austro-Hungarian school, 5 500 sheep were raised (Figure 39). The lambs were sold locally, 3 or 4 months old, between March and May. The herd spent the wintertime in Guber, in stables (5 on Figure 37). They were fed with grains and hay. Then, shepherds took care of them on summer pastures located close to Cincar (1, 2, 3 and 4 on Figure 37). Up there, "*it was a huge organization with workers, cookers and even doctors"* (H-Liv-012). The main site was in Begovaća (Figure 39).

Figure 39: Sheep breeding under Cincar in Livno. Source: Mljekara Livno[4].

The sheep's milk from the State farm was all transformed into cheese within the farm buildings. Before 1969, milking, cheese processing and cheese ripening were done on the pastures, from May to October (except the *Roquefort* cheese, ripened in the Duman cave in Livno). Cheeses were made from raw milk. In 1969, a semi-industrial dairy was built in the city of Livno, with the technical help of Zagreb dairy *(Zagrebačka Mljekara)*, another socialist structure. It was then integrated into Livno State farm. The main differences in the cheese making process were the use of pasteurization, the implementation of cow's milk for making cheese with both cow's and sheep's milk. Cheeses started to be produced all year round, exclusively out of cow milk from

[4] *Livanjski sir* i povijest Mljekare Livno (mljekaralivno.com) consulted in 21/06/2024 07h32.

November to April. The whole process – cheese-making and ripening – was relocated there. All the sheep's milk processed was collected from the pastures with milk tanks. At the same time, the dairy set contracts with local farmers for collecting cow's milk all over the study area. "*Farmers were mostly located in Livno, Tomislavgrad, Glamoč and Bosansko Grahovo. There were households with… maybe less than 10 cows.*" (H-Liv-12). This State farm had its own collecting trucks and routes, except in Tomislavgrad where *Poljoprivredno zadrugas Tomislavgrad* was operating. Another public company managed sales, mainly in Croatia, from Istria to Dalmatia. *"Croatian touristic coast was the main selling place, especially hotels and restaurants!"* (H-Liv-12).

Alongside with cheese production, piglets from 300 sows were fattened in Grborezi (Figure 37). The crop production section of the State farm produced all the hay and grains needed. It even "*sold 70% of the total grain production… locally… directly at the farm*" (H-Liv-10). Crops, sown grasslands and overseeded natural grasslands were the 3 cropping systems. Hay was produced on these grasslands. The 65 workers of the crop production section, who were also mechanists, had headquarters in the city of Livno (Figure 37).

The global functioning of the Livno State farm is presented in the Figure 40.

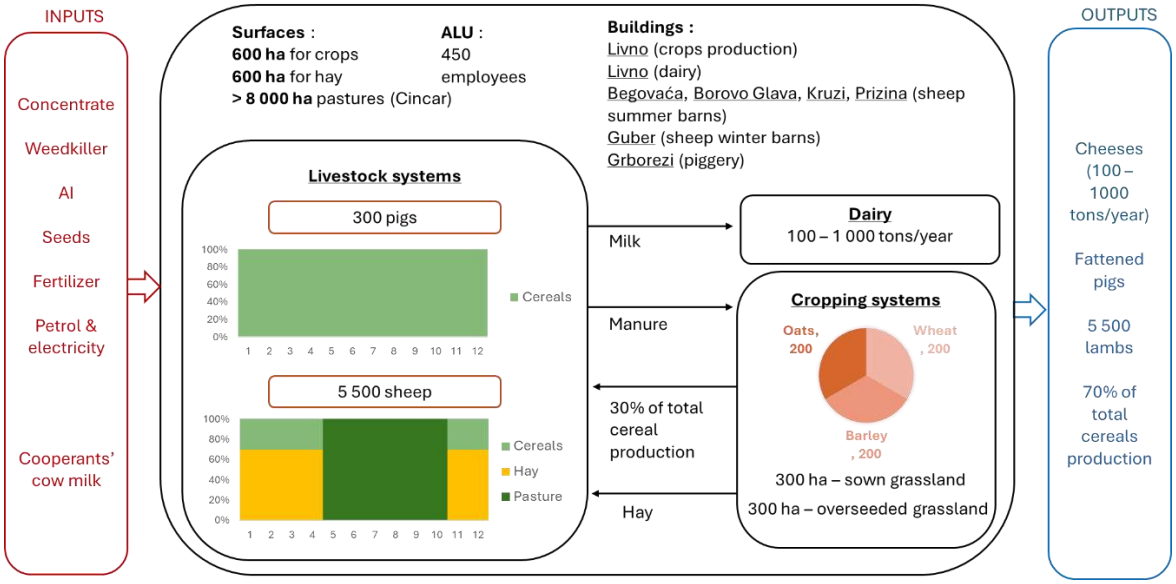


Figure 40: Livno State farm organization (1970's). Emmanuel Artus and Anouk Fraisse.

During the 1992-1995 war, Livno State farm processed everyday between 3 000 and 10 000 litters per day. It was completely dismantled and privatised between 1999 and 2001. The dairy was bought by a private company. Sheep winter barns and piggery were sold to private persons. Crop production headquarters were transformed into shops and cafés. Only sheep summer barns are still abandoned.

2.3.3. Kupres State farm for meat and cheese production

Named *Zrinovic*, the Kupres state-farm mainly produced lamb meat and cheese. Kupres State farm used both the poljes (1 to 5 on Figure 37) and karst plateaus (6 on Figure 37). About 20 000 ewes were raised over the year. The buildings for wintertime were in the poljes. The arable lands used for growing crops were nearby the buildings and hay was mowed further away. In total, it represented on 9 000 ha. Every summer, 5 000 pregnant cows from a State farm in Hercegovina joined the sheep herd in pastures – mainly in Hrbina (Figure 41). Altogether with the pastures, Kupres State farm managed 23 000 ha for 200 workers.

Figure 41: Ruins of former accommodation building for workers up on Hrbina. Hrustan Kadić.

Later on, during the 80's, one sate-owned dairy was built in Kupres for processing cow's milk produced by private farms. This milk was collected in Kupres (until the war) and Tomislavgrad (until 1985) municipalities.

Like Livno State farm, none of the buildings on *Hrbina* (the karst plateau) was bought during the privatization process. Buildings around polje were bought by private persons.

2.3.4. Glamoč State farm for meat and potatoes

On a similar functioning, Glamoč State farm yearly raised 1 000 sheep and 1 000 bulls. Animals grazed on Hrbina karst plateau for summertime and were kept in barns in wintertime. Glamočko polje was already famous its potatoes – which are protected as Glamočko potatoes PGI at the national level since 2024. It was grown for the state-owned company Glama, processing them into potatoes crisps. Some potatoes were also bought from the local private farmers.

"In primary school, our classes used to go altogether for harvesting potatoes in the State farm!" (H-Gla-02).

Glamoč State farm closed in 1986. Animals were all sold to Dalmatia, and there was an auction for selling the lands.

2.3.5. Tomislavgrad State farm for cow's milk production

Tomislavgrad State farm hosted up to 800 Prim 'Holstein for milk production. It was sold to dairies out of the actual Canton 10, such as in Split. On the study area, it was the only State farm not using pasture lands. Cows were kept in stable all year long. On the 800 ha of arable lands, grains, hay and corn silage were grown. In 1970, it was the first farm from the area making corn silage and keeping animals in stables all year round.

2.4. Summary: quantities and distribution of animals on the study area

In 1991, about 120 000 sheep[5] (Bernardoni & Estève, 2008) and 70 000[6] cows (both from private and State farms) were present on the territory. The accessibility to karst plateaus, especially close to the poljes (and thus villages) seems to be correlated with the number of animals raised (Figure 42). Indeed, the State farms were built in the more suitable places for agriculture and from where the karst plateaus were easily accessible (Figure 43). Moreover, they correspond to the most densely populated areas, allowing more private farms (of all types) and so, more animals.

[5] The 1991 household and agriculture Census reports 117,752 sheep in the whole Canton.
[6] We estimated the number of cows thanks to interviews concerning State farms, the 1991 household and agriculture Census, and historic interviews.

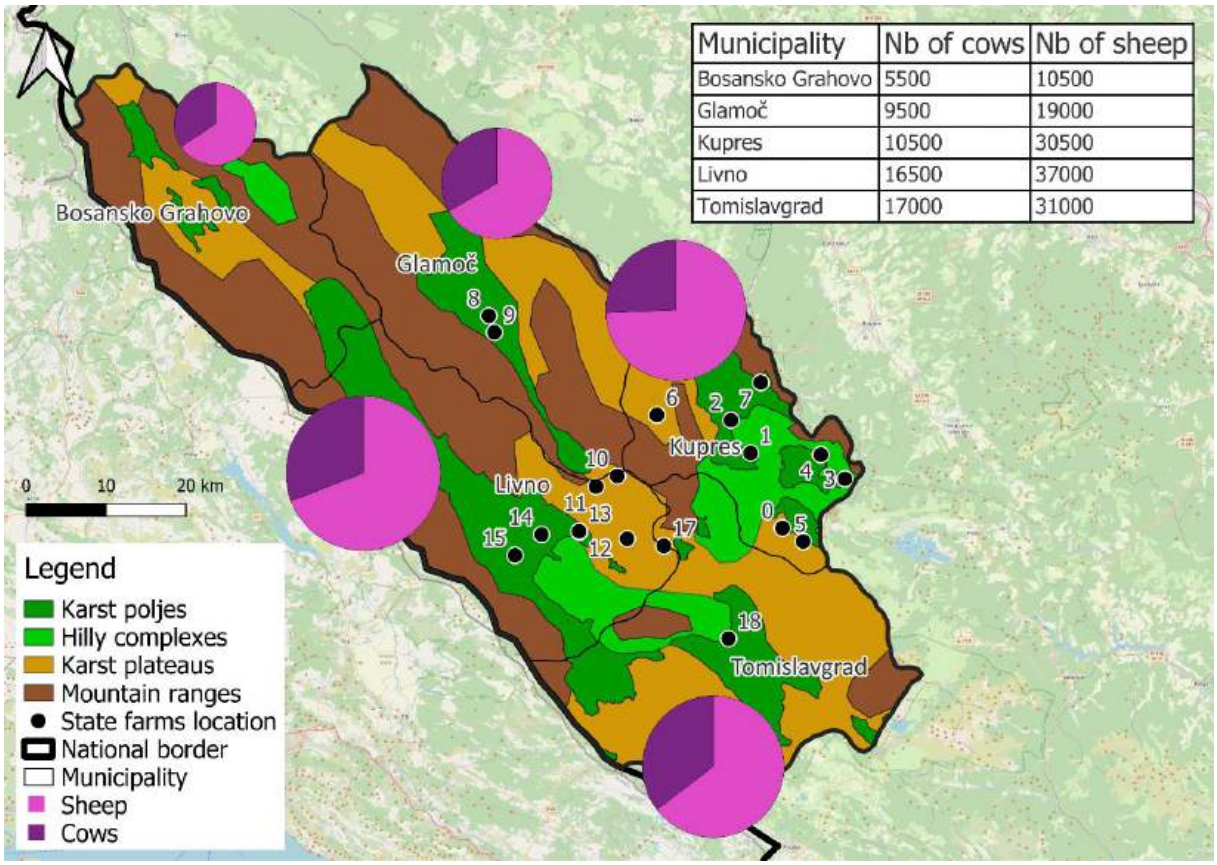


Figure 42: Livestock situation[7] and location of the operations of the State farms at the end of the 80's. QGis. Emmanuel Artus and Anouk Fraisse.

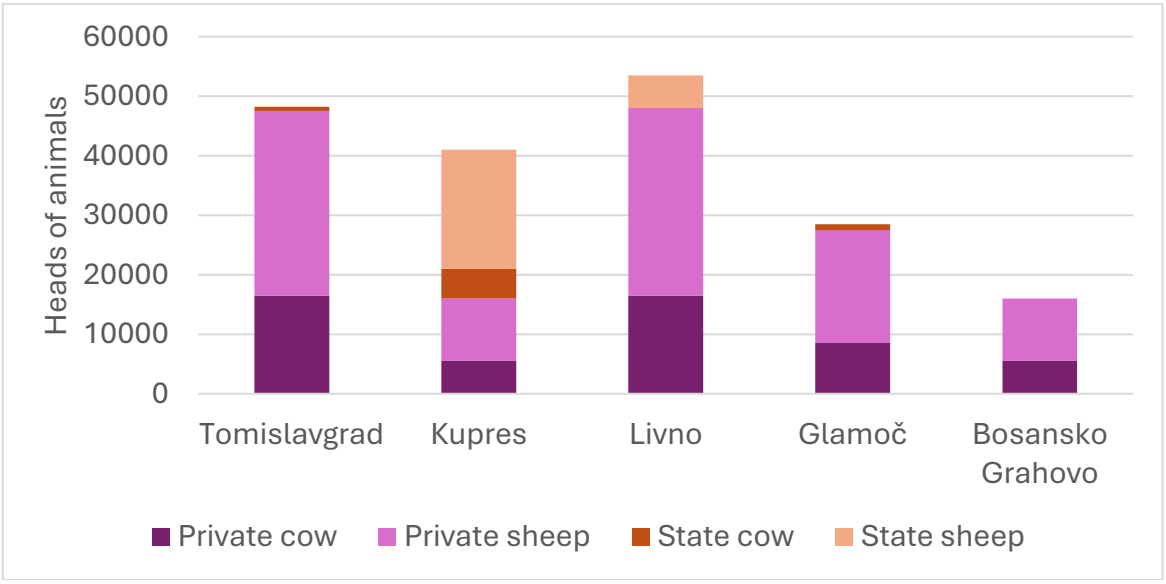


Figure 43: Number of animals per municipality and per ownership[8].

Between 1970 and 1991, intermediary zones became only used as pastures and not as lands for hay anymore as mechanization was not possible there. The most remote places in mountain

[7] We estimated the repartition of the number of animals thanks to interviews concerning State farms, the 1991 household and agriculture Census in Yugoslavia, and historic interviews.
[8] id

ranges started to get encroached as the agricultural activity was slightly decreasing and karst plateaus sufficient (Figure 44).

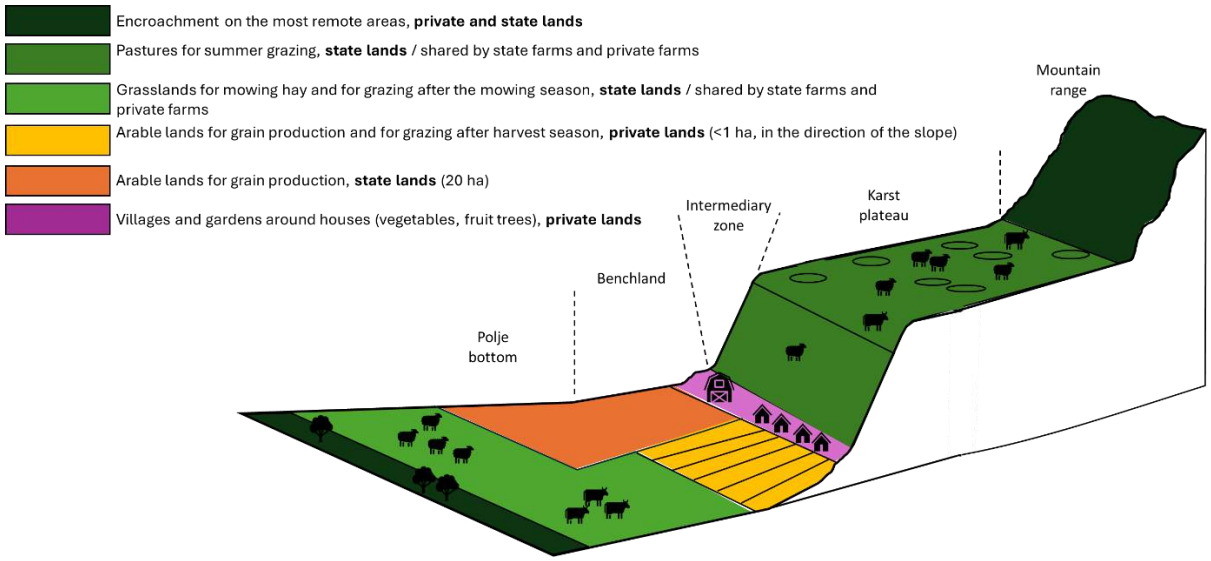


Figure 44: Cohabitation of private and public production systems on landscape units. Emmanuel Artus and Anouk Fraisse.

3. 1992-1995: population displacements and new national borders

3.1. The war in Canton 10

In 1992, at the fall of Yugoslavia, a civil war broke up between the major identities of BiH: Bosniaks, Croats and Serbs. In 1992 and 1993, Canton 10 was split between Croats & Bosniaks controlled zones and Serbs controlled zones (Figure 45). Around the frontline, complete destruction of the villages occurred; farms and cattle included. On the territories occupied by Serbs, Croats and Bosniaks left. On the Croat and Bosniak controlled zones, Serbs fled. Even away from the frontline, the houses of displaced people were destroyed even though it was not as systematic as around the frontlines. In 1993, tensions between Bosniaks and Croats appeared. As Bosniaks were way less numerous than Croats, they mostly left the Canton 10, being *persona non grata*. In 1995, the frontline was pushed back further into Serb territories. In Kupres and Bosansko Grahovo, it led to the destruction of Serb deserted villages.

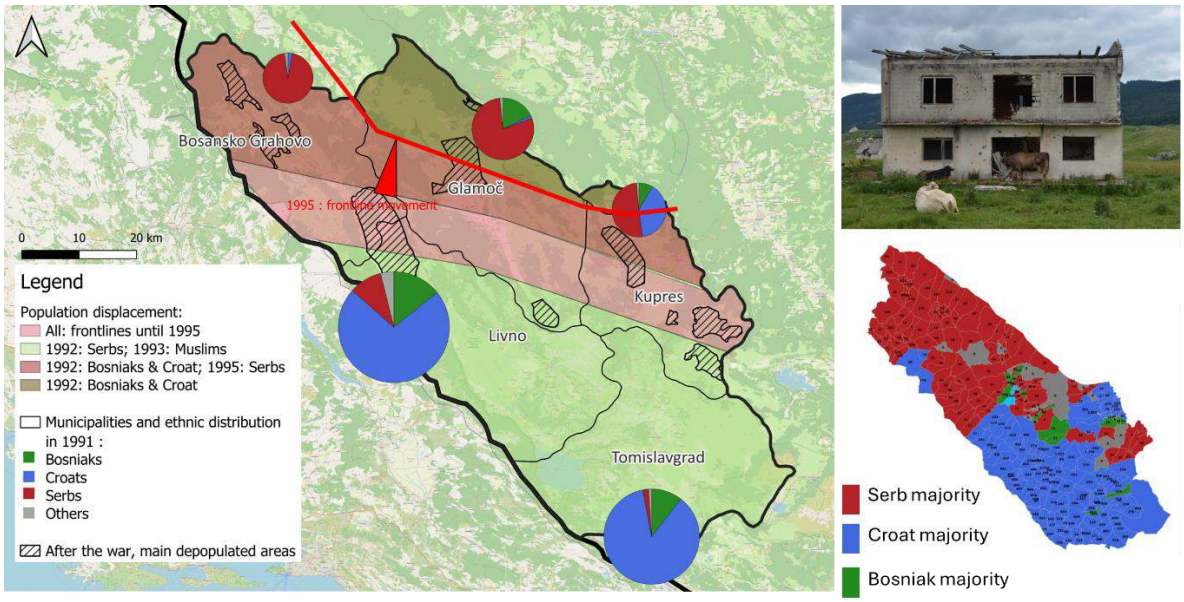


Figure 45: Left: population distribution, displacements and frontlines. QGis Emmanuel Artus. Upper right: destroyed house at the bottom of Malovan mountain, Kupres. Anouk Fraisse. Down right: current population majority from Bricault, 2023.

The displaced population mainly went to safer places within BiH, in bordering countries such as Croatia or Serbia, or in west European countries such as Germany and Austria. Of all the refugees coming to the European Union, Germany hosted almost 60% of them (Heimerl, 2002). They were mostly Croats and Bosniaks, while Serbs mainly seek safer places within BiH, in Serb controlled areas.

Eventually, systematic destruction of houses and farms occurred all over the northern part of the study area (around frontlines in pink colours on Figure 45). Herds were slaughtered, barns and machineries destroyed. Agriculture only maintained in Livno and Tomislavgrad, on a reduced intensity (light green, Figure 45). There, people "*never moved, kept on activities, and even hosted refugees from Bugojno"* (H-Tom-10).

3.2. New governance, public land management and subsidies as direct consequences of Yugoslavia dislocation

New borders between BiH, Croatia and Serbia appeared. Trade decreased drastically. This "unnatural" border with Dalmatia, was first circumvented by smuggling agricultural products, especially cheeses. Then, fines made these illegal trades almost impossible. To export cheeses and meat, pasteurized milk and hygienic norms based on EU standards became necessary. The border with Serbia impacted nomadic systems, which lost access to their main winter feed supply, in Vojvodina.

With the newly declared state of BiH came a new governance and a new way of managing the already existing agricultural subsidies. To end the conflict, BiH was split into 3 entities: Brčko district, Federation of Bosnia and Hercegovina (FBiH) and Republika Srpska (RS) (Figure 46). FBiH is divided in 10 cantons and cantons in municipalities. RS is also divided in municipalities. Ministries (including the agricultural one) exist at the national level of BiH, as well as at the entity level (FBiH and RS) and at the cantonal level.

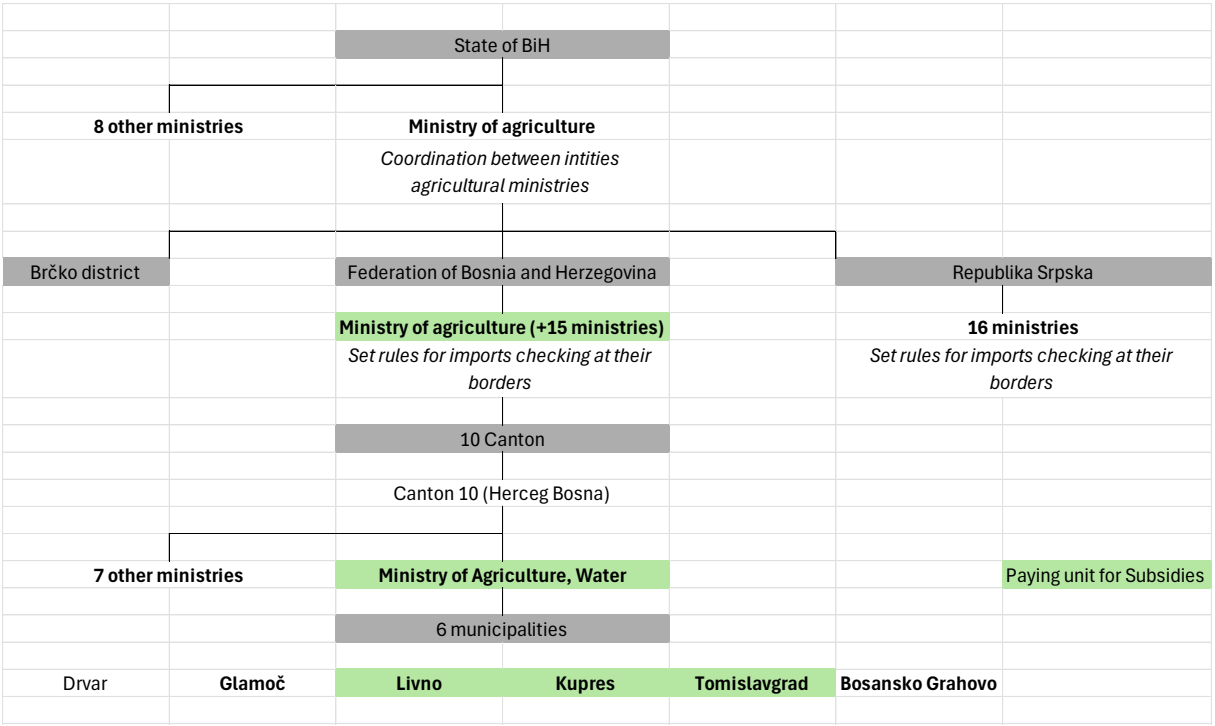


Figure 46: Governance of BiH. Emmanuel Artus and Anouk Fraisse.

The new countries became the owners of the public land. BiH never redistributed them to their previous owners, the state still owns them. According to the law, public lands are not for purchase. Anyone can rent and use them. Maximal rental prices (Table 2) are set by the cantons, according to their defined function (Annex). Right after the war, contracts of 25-year lease were signed. It means that today, some lands are still under these contracts. Since the early 2010's, leases last 1 or 10 years. Each time a new lease is to be delivered, there is a 3-months public call preceding an auction. If several farmers can offer the maximal price for the same plot, priority is given to the previous renter, then to the farm with the biggest herd.

Table 2: Maximal prices for public land leases (KM/month). Figures: Ministry of Agriculture and Forest of Canton 10.

		Land for crops	**Qualitative land for crops**[9]	**Land for hay**	**Land for pasture**
State-owned land	Initial rental price	80 KM/ha	100 KM/ha	60 KM/ha	40 KM/ha
	Maximal price after auction	160 KM/ha	200 KM/ha	120 KM/ha	80 KM/ha

[9] According to Canton 10 considerations: "which has been arranged and/or whose natural properties have a greater production potential".

4. 1996 - 2024: towards the current production systems and dairies

4.1. The direct aftermaths of the war (1996 – 2010)

It took years after the war for people to come back. It was progressive and lasted until late 2000's. Closed to the frontlines, most of them came back with their home destroyed and burnt. Far from the frontlines, their houses could have been sacked. The number of animals in the most impacted areas (Glamoč, Kupres, Grahovo) was almost null. It required time to increase again the herds and to reach a balanced situation. It was not the case before 2010, especially in the most impacted places and the newly built farms.

4.2. Traditional nomadic systems

After 1996, it was not possible anymore to cross Serbian or Croatian borders with living animals. As traditional routes crossed those borders (Figure 34), nomads suffered from a reduced access to pastures. Croatian nomad systems simply disappeared as they had no other options out of Bosnian Dinara for summer feed. For nomads from Travnik, the main issue was winter transhumance, which was then constrained to the Bosnian Posavina, the main crop production area of the country. Adding to a global disinterest for the nomadic style of living, especially from the youngest generation, nomad systems decreased after 1996. A lot of them settled down on their farms in Travnik. When it lands started to lack for farmers not doing transhumance, some of them settled down in Kupres where land pressure was lower.

The Hrbina karst plateau was slowly abandoned. Indeed, many animals are needed for maintaining summer pasture values: *"grass quality is good when they are a lot of animals. If you remove animals, you reduce grass quality on the pastures"* (H-Gla-05). In addition, they used to compact the soil of the dolines, where they were parked for the night. Soil compaction turned them into water pond for the following year. Winter rains and snows would be hold there for the next summer. This phenomenon stopped as the number of animals decreased. Shortly after 1996, families stopped producing cheeses in the pastures, water and workforce not being sufficient. Knowing all of that, it is easily understandable that nomad systems are now simply disappearing…

"Here, on Hrbina, were about 50 families in 1970! Now we are only 5…" (H-Gla-05).

On the typology (Figure 57), they are referred to as N (traditional Nomadic systems).

4.3. Traditional cheese-making systems

With the new borders, the main marketing channel – Dalmatia – became unavailable for traditional cheese producers. Indeed, exporting cheeses made from raw milk is forbidden. Moreover, since 1992, Bosnian laws prohibit raw cheese sales in supermarkets. Their main marketing channel became tourists, going through Livno on their way to Dalmatia. "*Every inhabitant from this Canton has a Croatian passport*" (H-Kup-00) and can go on vacation on the coast. Farms located nearby the main touristic roads made their own stalls and advertisements (Figure 47). Some farmers near those roads even started reselling activities. But selling cheeses on-farm is barely sufficient to earn a decent living. As a heritage of the traditional trades with Dalmatia, some producers kept on selling cheeses there, thanks to smuggling. When Croatia entered the EU in 2013, the border was even more strengthened.

"[Farmers] are risking everything!"; they expose themselves to pay fines "or worse, being left without any cheese" (T-Liv-09).

Figure 47: Advertisement on the road to Dalmatia, "Homemade Livno cheese". Anouk Fraisse.

Moreover, less and less farmers are taking their ewes to karst plateaus. As the cheese is of better quality when ewes are taken to pastures, farmers try to keep on preserving the tradition. However, 3 main reasons lead them to stop on doing it:

- the lack of water happening sooner each year (less and less water pounds on the plateaus)
- the difficulty to find shepherds
- and the complex cohabitation with the wild horses (especially around Cincar).

"[Shepherds] all go to Croatia and it's hard to find one here" (T-Liv-11), as they have better job opportunities there. Old people are not able to do it anymore and young generations are not interested in shepherding. Indeed, shepherds have a bad reputation; the word *"čoban"* ("shepherd" in BHS) is sometimes used as a negative term. Moreover, problems with alcohol consumption can happen: "s*ometimes they just leave with the money and spend it on alcohol and come back when they don't have any money left*. We have to check on them." (T-Liv-11).

The large number of wild horses is also seen as a threat by farmers. They are given feed, mainly minerals, to ensure that they stay on *Krug planina* (the karst plateau over Livno where farmers used to take their sheep), as they are one of the main tourist attractions of Livno. *"Salt is even left to attract the horses… for the tourists…"* (H-Liv-014). Ponds have also been restored for them (Figure 48). However, *"sheep are scared of the horses"* (T-Liv-11). They eat grass and they are too numerous for the water availability, *"horses come, they eat all the grass around and the sheep can't eat… there is nothing left for us!"* (H-Liv-014).

Figure 48: Ponds for wild horses, Krug Planina (Begovaća). Anouk Fraisse.

Facing this lack of water, farmers started bringing water cistern for July and August. However, it represents a lot of work for an activity that is already time consuming. It becomes one more

reason to stop grazing in the mountains and stay in the intermediary zone of the poljes, closer to the farm.

In the late 2000's, those farms also faced Brucellosis. *"Policy was to kill sick animals and vaccinate the others to stop the disease"* (H-Kup-05). Along with difficulties about cheese sales and shepherding, traditional cheese-making systems decreased. For example, over the 30 *Livanjski sir* on-farm producers in 2000, only 5 are still active today. Others, if not retired, sell their milk to dairies. *"It was too much work to keep the sheep when the children left home, so we focused on dairy cows"* (H-Kup-05). Younger generations are not interested in cheese-making considering the small money earned for the big amount of work.

Animal feeding remained similar to what was done before the war. Farmers kept their know-how and produced the same cheeses. Fermented feeds are considered as a problem for cheese taste. They were no farm creation for on-farm cheese processing. Here is the diversity of cheeses made on-farm, that we met or heard about (Table 3, underlined cheeses are the main products of those farms). On the typology, they are referred to as CL (Figure 57).

Table 3: Diversity of cheese production in Canton 10, rough estimations. Emmanuel Artus and Anouk Fraisse.

Type of cheese	**Farms interviewed/seen**	**Observed locations**	**% of cheese-making farms producing this type of cheese***
Livanjski izvorni sir	5 farms	Komorani, Guber, Grborezi	~ 20%
Sheep and cow's milk hard cheeses (not produced in Livno)	1 farm	Outside Livno	>10%
Cow's milk hard cheese	13 farms	Malovan, Busko jezero dam, Livno market, Komorani, Guber, Grborezi, Vukovsko	60% **
Goat's milk cheese	2 farms	Bosansko Grahovo, Šujica	< 5%
Vlašićki sir (sheep's milk cheese)	1 farm 1 farm in Livno market	Dolac, Livno market	> 5%
Fresh cheese (for sirnica)	4 farms in Livno market	All study area	~ 20%
Kajmak	Few farms	North of Kupres municipality, Srpska Kupres (RS)	~ 15%
Butter	Almost all cheese producers, for household use	All study area	95% (household use)

** Rough estimations based on the number of interviews carried out, people's affirmation and on-field observations.*
*** Includes farmers having less than 10 cows and only living on cheese production (Malovan), farmers selling a part of their milk to dairies and producing some cheese in summer (Livno market, around 3 cheeses on the stalls every week), farmers producing Livanjski izvorni sir in summer and cow's milk cheese in winter.*

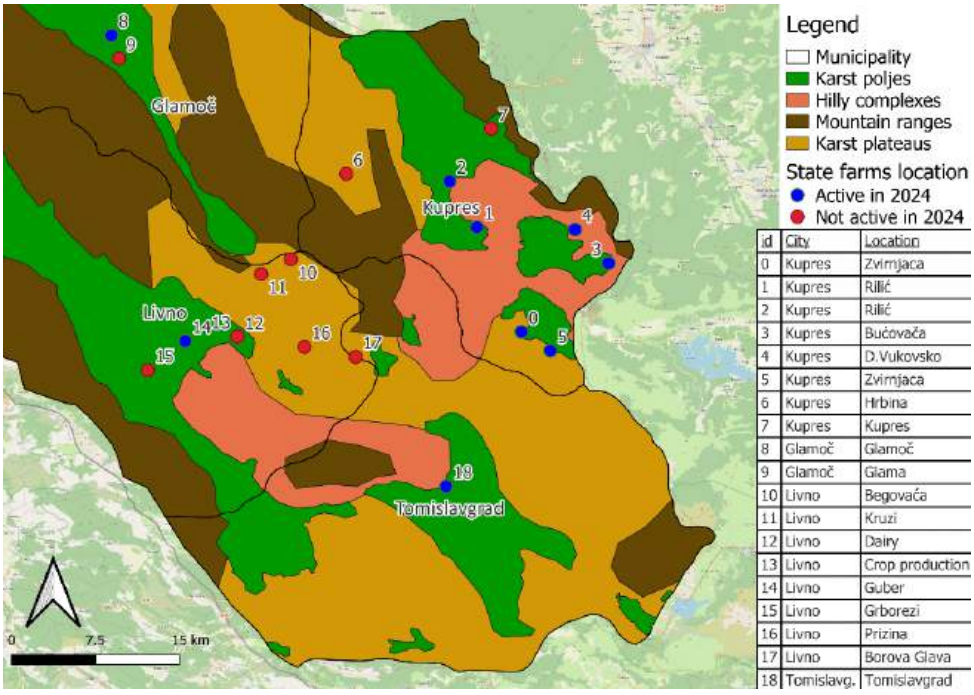
4.4. From State farms to megafarms and private dairies

With the fall of Yugoslavia, State farms stopped operating and were privatized. Most of the buildings were bought for "one symbolic mark", with their surrounding lands (~10 ha). It was a policy of "first arrived, first served" (H-Kup-00). If we only consider the 3 largest structures which bought State farms' buildings, they lease about 60% of the total arable public lands. In the context

of immediate post-war, on a territory with Croat majority, political relationships might have been important for accessing these lands. At the end of the land lease, the prior renters are prioritised for the lease renewals. Since 1996, their presence on the territory is ensured.

Tomislavgrad State farm buildings were bought before 1998. It first served for meat production on 640 ha of public lands. After facing economic difficulties in 2006, the farm was sold to the current owner, who was already managing a similar operation in Posušje. The municipality redistributed 160 ha of arable lands to local farmers, and the new operation was left with the remaining 480 ha. Quickly after, the same owner was entrusted about 300 ha of arable lands from Glamoč previous State farm. Starting with 150 dairy cows in 2006, the operation in Tomislavgrad has reached 560 dairy cows and hundreds of bulls for fattening in Glamoč (8 and 17 on Figure 49). Material and manpower are sometimes shared between the two locations, but livestock systems are completely decorrelated. We focused on the dairy farm, which we named M-XL in the typology (Figure 57).

In 1996, almost all Kupres State farms buildings were bought by two different individuals. They started two different businesses on a large majority of public arable lands. One of them started breeding Angus on a cow-veal system. It still is its main activity today, even though the owner later started bull fattening operations, not only on previous State farm buildings (1, 2, 4, 5 on Figure 49). They were mainly built after 2010, when BiH started subsidizing meat production systems. The number of animals increased reaching 3 500 cows for 3 500 ha of arable lands (2 500 ha for hay and 1 000 for crops) and 3500 ha of pastures. This structure is referred to as CV-XL (Megafarm (XL) on Cow-Veal system) on the typology (Figure 57). The second buyer focused on sheep breeding and milk transformation. Over the last 10 years, the farm stopped producing cheeses, only raising sheep for lamb meat. A larger unit for crop and herbal productions on several hundreds of hectares was developed in partnership with a Croat international brand (0 and 3 on Figure 49). It became the main operation, that's why we named it Cr-XL (Megafarm (XL) for CRops production) in the typology but we never modelled them as they were not willing to discuss (Figure 57).



id	City	Location
0	Kupres	Zvirnjaca
1	Kupres	Rilić
2	Kupres	Rilić
3	Kupres	Bućovača
4	Kupres	D.Vukovsko
5	Kupres	Zvirnjaca
6	Kupres	Hrbina
7	Kupres	Kupres
8	Glamoč	Glamoč
9	Glamoč	Glama
10	Livno	Begovača
11	Livno	Kruzi
12	Livno	Dairy
13	Livno	Crop production
14	Livno	Guber
15	Livno	Grborezi
16	Livno	Prizina
17	Livno	Borova Glava
18	Tomislavg.	Tomislavgrad

Figure 49: State farm building location and current activity of these buildings. Emmanuel Artus and Anouk Fraisse.

Since 1996, all those operations are the most mechanized over the study area, from stables equipped with scrappers to hay sprayer, almost none of the practices is done by hand (Figure 50).

The production systems implemented managed large areas of arable land allowing them to produce winter feeding (silage, grains and hay). For this reason, former barns in the middle of karst plateaus remained abandoned. Indeed, they are far from the polje state-owned arable lands (Figure 49). The two state dairies never stopped working and were privatized. In Livno, even if ownership changed a few times, it kept on operating. In Kupres, the state-owned dairy processed cheeses until 2015, when it faced financial issues. Another dairy developed on the former disaffected State farm slaughterhouse.

Figure 50: Example of equipment on megafarms. Anouk Fraisse.

4.5. Side farming in households decreased

People who kept their job despite the war (especially in Livno and Tomislavgrad) continued having a small agricultural activity aside their non-agricultural work. Animals feeding and machineries are the same as before 1992. As family size decreased and children went for longer studies, the workforce diminished. Thus, household focused on a single production (dairy cow, potatoes, sheep, or even the sale of hay). As cow milk was still collected by dairies after the war, most of the side farms specialized on it. Glamočko potato was already famous and is also grown by many in Glamoč.

Since 1996, the number of side farms is dropping as young people have non-agricultural work and don't see farming as their priority. It became an activity for pensioners or quite old employees, leaving many lands unused on polje bottoms and intermediary zones. The remaining farmers try to maintain arable lands as open as possible.

"I don't want to let the properties go wild and turn into forests, it is what happened in Kočare, so I keep mowing even if it's hard to sell" (H-Liv-04)

In our typology (Figure 57) they are referred to as S (Side-farming systems for cow milk production) and SO (Side-farming systems for other production).

4.6. Development of farms, without side-jobs, for milk production

After the war, the number of people returning to their previous houses varied between municipalities of the study area. On the most destroyed places, people were less likely to come back (Bosansko Grahovo, for example). In the municipality of Tomislavgrad and the southern part of the municipality of Livno, a large proportion of people came back. Returns depended on the opportunities people had to stay in their refugee places.

"Some people have been forced to come back… because they had no funds to buy houses where they were."
(H-Kup-03)

Loads of people returning faced unemployment. It could be because previous hiring structures such as industries and State farms were now closed, or identity discriminations. Thus, a lot of them started building farms, whether they had a farm or not before the war. People went for dairy farms as Livno dairy was still collecting milk over the study area. Moreover, returning programs often "*provided people with one pregnant heifer*" to support dairy production (H-Kup-00). The very large majority produced cow's milk, goat's milk production systems were rare, sheep's milk production systems inexistant.

4.6.1. Small family farms for Milk production

As people focused on agricultural activities (without any side job), they had to reach around 15 Simmental cows or 60-70 Alpine goats to achieve economic viability. These family farms usually started with the small barn from the house that remained from before the war. They managed the few hectares they were allowed to possess during Yugoslav time. They were also entrusted with the mowing of their relatives' lands who never came back after the war.

"It is not economically viable with less than 10 cows, if the milk is your only income" (H-Tom-06)

Animals were freely brought to public pastures on intermediary zones (above houses) from May to August (mowing season), then on the polje bottom for aftercrops (*livade*) until wintertime and the firsts snows. Goats stayed all grazing-time on the intermediary zones, barely coming inside the polje. Barley, wheat and oats were sown on about 5 ha of private lands, rotating with natural grassland. Along with the hay – both produced on private lands and polje public lands, it was used as animal feeding in winter.

These farms had not a lot of money to invest in imported tractors or equipment. They started by using the same tractors as the ones used for side-farming before the war. To carry out the higher quantity of work, they invested in the missing tools for crop and hay production and for milking cows. They renewed their tractor implements faster than side-farmers, and with larger pieces (especially mowers and windrowers, Figure 51).

Figure 51: classic equipment on a small family dairy farm (mower, windrower, baler, plough, milking pot). Anouk Fraisse.

It was common come back without children after the war, who stayed with relatives living where they had found accommodation during the conflict. The needs for the couple were small, as well as workforce, and those farms didn't grow much more. They still exist today, and we named them S-M (Small farm for Milk production) in our typology (Figure 57).

4.6.2. Medium family farms for Milk production

With bigger families, more hay was collected, feeding more animals and producing more milk at the farm scale. The money that came from these extra sales (in comparison with small family farms) was invested in larger material, such as round balers rather than square balers. About 2010, fermented feeds requiring new equipment were introduced in those family farms (Figure

52). They grew corn for silage and grasslands with clover for haylage. Water supply is usually enough for the growth of corn. More feed was produced on the farm, bringing the average number of animal in those farms about 40 Simmental or 200 goats. Once again, the number of goat farms was anecdotal compared to cow farms.

Figure 52: classic equipment on a medium family dairy farm (tractor with round baler, mower, haybale, windrower, truck with round bales, milking machine, corn silage harvester). Anouk Fraisse.

Although more feed is produced in summer, these farms kept on using pastures. Today, the cows graze public lands on karst plateaus between May and August. Then, they go on private and public arable lands on the polje for pasturing aftercrops. During summertime, animals are given small quantities of fresh plants picked on grasslands or even crops. With the silage in wintertime, cow milk production became higher than for M-S (about 3000 L/cow/year). It is mainly sold to local dairies.

We named these production systems M-M (Medium family farms for Milk production) in our typology (Figure 57).

4.7. Dairies

For exhaustive information on dairy value chain, report to *Slijepčević, 2024* (forthcoming).

Only two dairies operated through the war and right after it. One was from Kupres state operation, the other from Livno state operation and both got privatized around 2000. Processing technics did not change. *Livanjski sir* and *Kupreško Sir* were produced respectively in Livno and in Kupres.

After the war, 3 families started smaller *Livanjski sir* production on their farm. They stopped breeding animals to focus on cheese making, buying milk from neighbours and relatives. Since 2010, two similar structures were created, not producing Livno cheese (Figure 53). In total, 7 dairies were created (and are still active today).

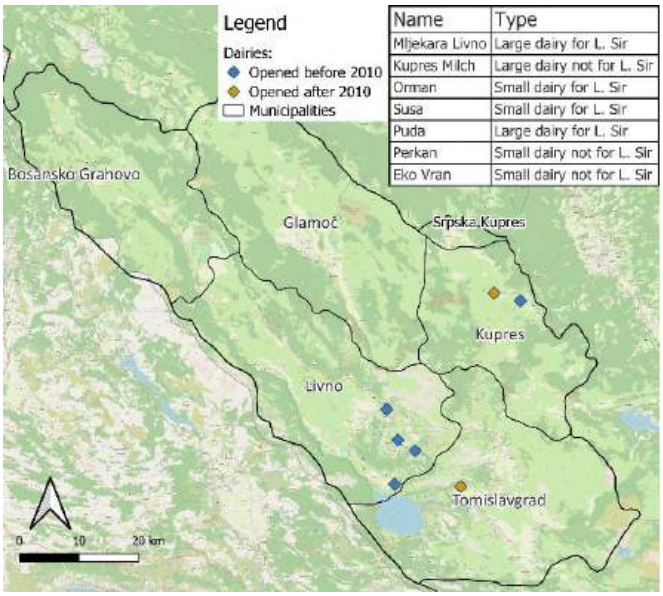


Figure 53: Location of dairies on the study area. Emmanuel Artus and Anouk Fraisse.

After 1996, with the end of State farms – that produced most, if not all, the sheep's milk processed in dairies – sheep cheeses stopped being produced at large scale. It could only be found in traditional cheese making systems as they were the only ones raising sheep. For one decade, dairies only collected cow's milk. During the late 2000's, the two large dairies producing Livno cheese (Figure 53) started goat cheese production.

All the dairies pasteurized milk and got semi-industrial equipment (Figure 54). The three large dairies supply chain was then composed of small and medium family farms for cow's milk production. In 2010, each dairy worked with about 100 to 400 farmers. The two small dairies worked with about 10 medium farms. There was a bigger turnover in suppliers of large than small dairies.

Figure 54: dairy typical equipment in the study area. Pictures from Puđa dairy.

After 2010, the two dairies from the previous state organization had financial difficulties. One of them closed while the second one was bought by the current owner of Kupres Milch. Adding the Covid crise, the quantity of milk processed in Kupres dropped – farmers turned for dairies in Livno or Bugojno (Table 4).

During the same time, two national dairies entered the study area for collecting milk (Ducat and Meggle). With all the other dairies, they collected the large majority (>90%) of the total quantity of milk produced on the study area in 2010. This proportion slightly increased in the past years, reaching more than 95% while there are less and less cheese making systems. Dairies still are the only actors in the milk value chain able to sell their products in local supermarkets, and to export them.

Table 4: Quantities of processed milk from the Canton per dairy, and parts of the GIs according to dairies' assessions. In italics, weighing based on the interviews. Emmanuel Artus and Anouk Fraisse.

		Total quantity of milk processed (L/year)	Quantity of milk processed into PGI *Livanjski sir* (L/year)	Quantity of milk processed into PDO *Livanjski izvorni sir* (L/year)	Quantity of milk produced in the study area (L/year)
Traditional cheese makers		*500 000*	0	160 000	*500 000 (100%)*[10]
Cantonal dairies	Mljekara Livno	11 000 000	5 000 000	0	*8 800 000 (80%)*
	Puđa	5 500 000	2 500 000	0	*4 400 000 (80%)*
	Orman	600 000	360 000	0	600 000 (100%)
	Suša	220 000	200 000	0	220 000 (100%)
	Kupres Milch	350 000	0	0	100 000 (30%)
	Eko Vran	*300 000*	0	0	*300 000 (100%)*
	Perkan	250 000	0	0	250 000 (100%)
				Intermediary total (L/year)	15 100 000
Dairies outside the Canton	Meggle	[50 000 000; 130 000 000]	0	0	*3 900 000*
	Ducat	43 000 000	0	0	*1 100 000 (2%)*
				Total (L/year)	20 100 000

Supply chains depend on the size of the dairies. Large dairies (Mljekara Livno, Puđa, Meggle and Ducat) have a large numbers of suppliers. For example, today Puđa has more than 150 farmers. Since 2000, this number decreased as side-farming systems are less and less numerous on the study area. Nevertheless, they still represent a third of dairy milk supplies. To make it more attractive, and thus securing their milk supplies, dairies have been installing milk tanks in villages since 2010. They are shared by several households. They also enable dairies to spend less time collecting milk (Figure 55). Large dairies highly depend on milk from medium family farms. After 2010, they have constant deliveries of large farms (Large farms *for* cow's milk production on unused arable lands) and even occasional deliveries from the megafarm for cow's milk production.

Figure 55: shared lactofreeze. Anouk Fraisse.

[10] In brackets are the proportions of the milk produced in the study area on the total quantity of milk processed in each dairy.

All the smaller dairies depend on a reduced number of farmers (10 or less) who remained more or less the same over the years. They were small farmers when dairies were created, and they all grew to medium family farms (M-M).

All the dairies collect cow and goat milk with different trucks to produce cow or goat cheeses. For producing *Livanjski sir*, none of the dairies sort the milk regarding of the way it has been produced.

On the study area, the dairies' policies on price evolved from been correlated to milk qualities, to milk quantities. Nowadays, milk price is only based on litters sold. It goes from 0.95 KM/L for the biggest producers (see Large farms for cow's milk production on unused arable lands) to 0.75 KM/L for the smallest (side-farmers).

4.8. Process of protecting *Livanjski sir*

After 1996, it was difficult to sell cheeses in Dalmatia. Sales prices for cheeses in BiH are lower than on the coast. Moreover, in BiH, "*every place has its own cheese, so the domestic market is not wide*" (H-Gla-02). On-farm producers had to find a way to keep on exporting cheese to Dalmatia. Taking part to international cheese events, some farmers imagined labelling their knowledge of making *Livanjski sir*. In April 2007, the Cincar Association was created including around 30 on-farm producers and the 4 dairies of Livno. On-farm producers aim was to be able to sell their cheeses in Dalmatia. Dairies' purpose was to obtain a premium price for their main product.

"[On-farm producers] don't even need the EU, only Croatia, only Dalmatia" (H-Liv-09).

But goals were not the only contention points between on-farm producers and dairies. Disagreements appeared during the writing of the book of specifications. While on-farm producers wanted to promote cheese made from raw sheep's and cow's milk, dairies pushed for pasteurized milk and the possibly of doing Livno cheese only with cow's milk. The dispute lasted from 2007 to 2016, and no agreement was found. To unlock this situation, the Food and Safety Agency (FSA) – the competent commission for registering Bosnian GIs – signed in two GIs, one PDO and one PGI, on Livno cheeses. The PDO was carried by an association of on-farm producers: *Udruga Proizvođača Autohtonog Livanjskog Sira "Cincar"* (Association of Producers of Autochthonous Livno Cheese "Cincar"). They protected a cheese exclusively made from raw milk and a mix of sheep's milk (minimum 70%) and cow's milk. The PGI was carried by the four diaries, who allowed both raw or pasteurized milk and cow and/or sheep milk in their BoS. They are gathered under the association U*druga Za Zaštitu Podrijetla Livanjskog Sira* (Association For The Protection Of Origin Of Livanjski Cheese). Both BoS were deposited in 2019 at the Bosnian level. After being accepted, the PGI went for EU registration through the FSA national frame. The PDO is still waiting for special legislation for selling and exporting raw cheeses at the Bosnian level… at standstill for more than 5 years (H-Liv-09). They found themselves cornered by the situation as they still cannot export their cheeses to Croatia. They see no other issue but the disappearance of their farms and know-how.

"In 5 years, this farm won't exist anymore." (H-Liv-014).
"We are just waiting to enter EU." (T-Liv-09).

As a first step to be allowed to export, an Italian NGO and the Czecz Development Agency (CzDA) helped the on-farm producers to comply with hygienic rules. They provided them with processing equipment respectively in 2011 and 2016-2017[11]. Among the producers who were helped, some of them were not making *Livanjski sir*. CzDA also rehabilitated a place given by Livno municipality

[11] Sustainable Production of the Traditional Domestic Livno Cheese (czechaid.cz) consulted 19/06/2024 10h25

for ripening and selling cheeses. Nevertheless, this place never worked because of organization and trust issues among producers who were supposed to sell the cheeses.

4.9. Since 2010: Large-scale production systems developed on unused lands

Since the war, villages historically inhabited by the minorities of the area have never been fully repopulated. As time passed by, the people who came back grew older and became unable to manage the land. Thus, huge areas were left empty (Figure 56).

As a heritage of former Yugoslavia, a large proportion of the population have a Croatian passport, especially around Livno and Tomislavgrad (Figure 45). Since Croatia entered the EU in 2013, many of them chose to work in EU (Germany, Croatia) because of better job opportunities. They turned their formers homes into secondary houses, for summer use. Their agricultural lands were not used anymore (Figure 56).

"Population in Livno is decreasing… the only moment when it didn't decrease was during Covid, when people momently came back from Germany!" (I-Liv-03).

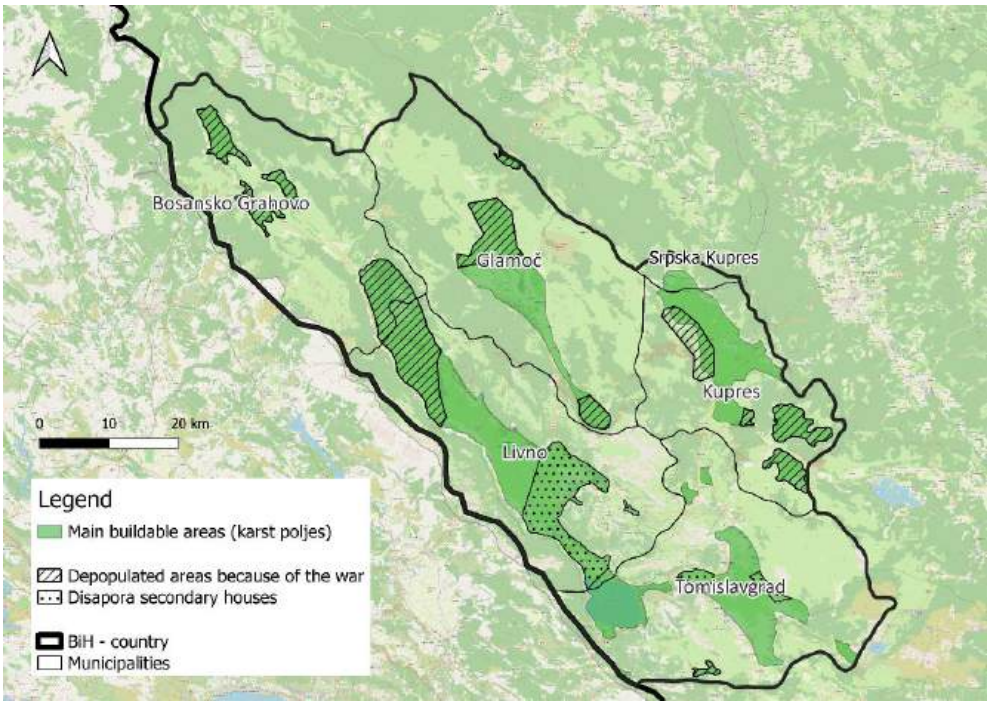


Figure 56: Less populated zones on the study areas. Observations and interviews. Emmanuel Artus and Anouk Fraisse.

4.9.1. Large farms for cow's milk production on unused arable lands)

About 2015, investors started leasing arable lands around Tomislavgrad, from people who were not using them as well as some from the state. They were not rooted in agriculture and came from other sectors. Some of them decided to work on the farm, other entrust it to managers. On the land they owned (through family heritage), they built barns and stables for cows or goats. They bought the latest equipment, as adapted as possible to small plots (around 1 ha). On the leased arable lands, they produced feed for animals. The main production has always been milk, sold to local large dairies and the production of *Livanjski sir*.

In Tomislavgrad is the biggest cow dairy farm over BiH (previous State farm). They manage Prim' Holstein feeding on the same rules: exclusively in stable, adapted on the lactation period, mostly composed of corn silage with high quantities of concentrates. The main difference was the size of plots. In fact, these new farms only had access to small private fields (up to 2 hectares) while their reference only used large public lands (about 20 ha each). These systems are still increasing, but knowing that, they "only" aimed 300 cows. We named them production systems L-M (Large farms for Milk production) in our typology (Figure 57).

"We cultivate 200 hectares… on… 180 plots! We're losing 30% of the time just moving the machinery from one place to another." (H-Tom-07).

The large quantity of milk produced by each of these farms let them negotiate prices with dairies (up to 0.90 KM/L). Those farms currently consider associating for negotiating prices all together.

4.9.2. Farms for goat's milk production

Since 2015, investments on goat farms for milk production have been done. On the study area, we identified less than 5 such farms. From one farm to another, practices were not the same from the beginning.

Half of these farms produce its own feed on previously unoccupied arable lands and use pasture lands for grazing. Goats are outside every day and are complemented with hay during wintertime when pastures don't produce enough. Bought concentrates are given all year long to ensure milk production. Equipment rather small, being composed of mowing equipment and milking stalls. They are assimilated to medium family farms (M-M).

The other half were constructed on a small plot, without any field for crop nor hay production. Goat stayed in the stable all year round and are fed with hay – bought to local side-farms – and concentrates – produced out of the study area and purchased in shops. Equipment is minimal: one tractor for mowing hay bales, and milking stalls for goats. We assimilated them to fattening systems (see the following part).

4.9.3. Fattening production systems

Half a dozen of off-land systems was created in the study area. They are mostly pig fattening production systems and chicken breeding. The animals are imported from EU at a young age before being fed with bought cereals coming from other parts of BiH. Animals stay in stable all year round. We named them F in our typology (Figure 57).

4.9.4. Cow-veal and ewe-lambs production systems on unused pastures

On the less populated areas (Figure 56), there are no farm and so a lot of available lands. This is especially the case for pastures – which were already abandoned since 1970 in some places. Moreover, in 2010, meat production started being subsidized by the FBiH. All over the Canton, new farms for meat production (bovine and sheep meat) were created. There were also some farmers who gave up on cheese or milk production and started meat production.

*"[New farmers] think that raising lambs is easy money" (*H-Gla-08).
*"The one who owns sheep owns the mountains" (*H-Gra-05).

On cow-veal systems, investments are numerous. There are the first animals to buy, the realization of the water network (water drilling or river pumping), the construction of a bigger barn or the purchase of material for growing crops. Starting such business requires a lot of investments – at least 1 million mark. The ones who can afford it often have comfortable situation before. It could even sometimes be investment farms. Those farms are often subsidized by European Union

funds for EU integration. Grants could be about one million KM (~500 000€). The quantity of animals (about 300 for those production systems) fed with pastures more than 8 months a year, requires large grazable areas. For managing pastures, farmers set electrical fences. Thus, they need to have proper contracts for using public pastures, which sometimes requires a certain network of acquaintances. It may be a reason why cow-veal systems are closed to the main economic places (Livno and Tomislavgrad) from the study area.

On the study area, we identified one main importer of cows from West European countries (Salers, Aubrac, Limousine). Working on the herd genetic, two farms specialized on selling pregnant heifers for people starting cow-veal systems. These new farms raise calves up to 5 months, to be sold for fattening outside of Canton 10. We considered these last farms for our typology and named them CV (Cow-Veal production systems).

Ewe-lamb systems are always set on the family farm they might have left being younger. They are present all over the study area, even though their proportion is higher in the northern part where the quantity of empty pasture is larger. Accommodation and some pieces of machinery may already be available. The main investments are then the first animals and the (re)construction of a bigger barn and missing material for mowing hay. Local breeds (*Travniška* and *Kupreška Pramenka*) are easily purchasable in the study area. So, starting such business requires rather low investments. Those farms raise about 300 ewes, complemented with hay and cereals during wintertime. Those farms often hire a shepherd, to graze on unused pastures. These shepherds are seasonal workers, difficult to find as Dalmatian tourism offers better opportunities. Those farmers don't usually have contracts for those lands as they don't set fences as cow-veal systems. We named these production systems EL (Ewe-Lamb production systems).

5. Summary: typology, and quantities and distribution of animals on the landscape

The result of this history is the coexistence of production systems with 560 dairy cows, and farms counting 5 cows. Their history is resumed in Figure 57. In number, the smallest farms are the more represented. For example, among all the milk producers, they represent 70% of the total number, for 15% of the total milk production on the study area (Figure 58).

To produce *Livanjski sir*, the origin of the used milk is described in Figure 59. The two large dairies producing Livno cheese still buy 25% of their milk to side-farming systems. As those ones are decreasing in number, those dairies built – or plan to build – their own farm on medium (M-M) and large (M-L) farms for milk production models. Two goat farms are already working, and at least two projects for cow farm are forecasted. The two small dairies still only rely on medium family farms.

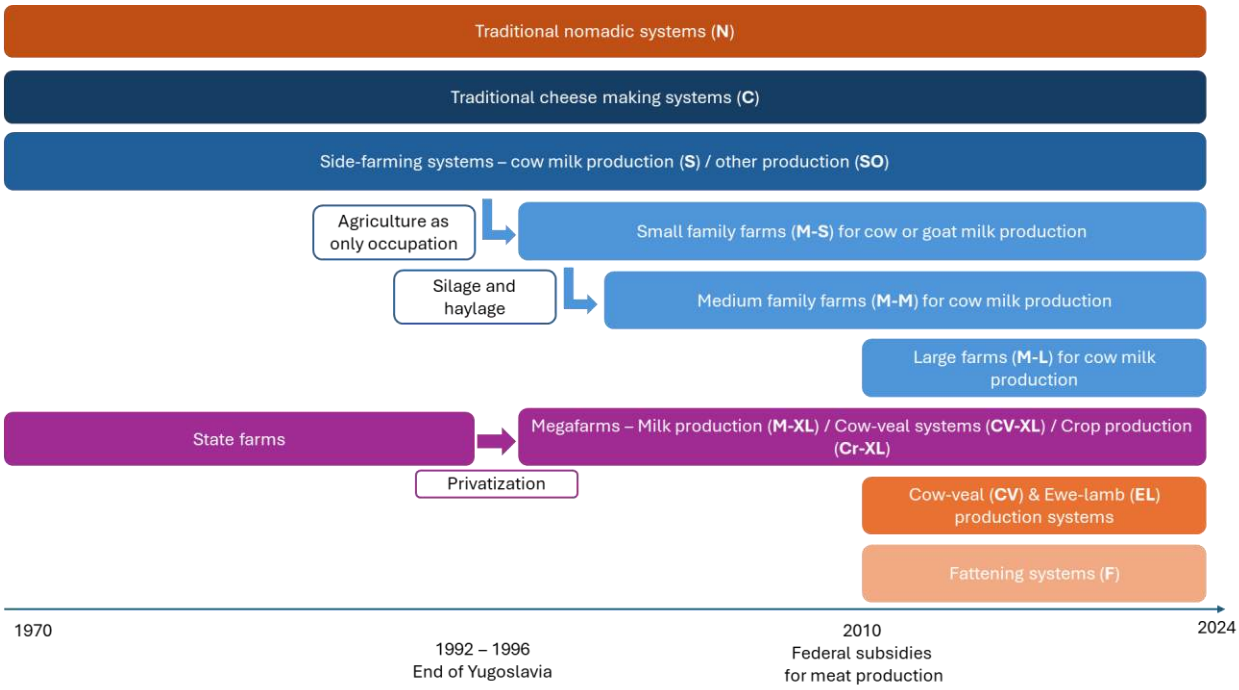


Figure 57: Agrarian history of the models. Emmanuel Artus and Anouk Fraisse.

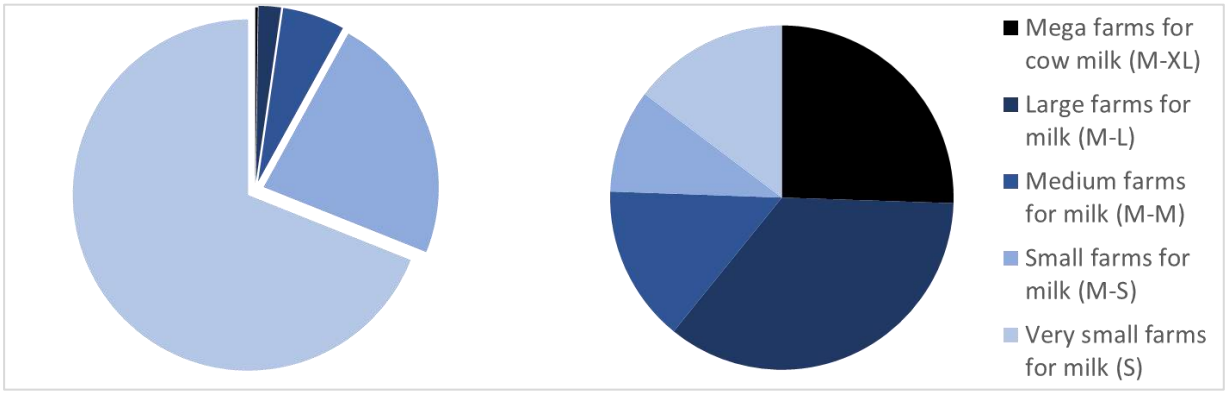


Figure 58: Left, number of farms per type – Canton 10 census. Right, quantities of milk produced per type – estimations based on the census and our models. Emmanuel Artus and Anouk Fraisse.

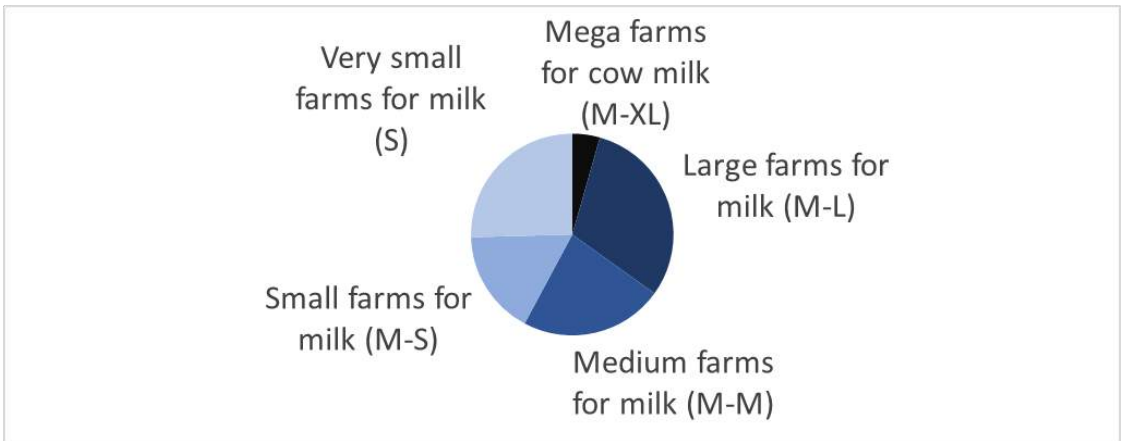


Figure 59: Supply chain for the 4 dairies producing Livno cheese. Estimations from Canton 10 census, dairies statistics and our models. Emmanuel Artus and Anouk Fraisse.

Nowadays, the most remote places are turning into forest. On the benchlands, because of less agricultural activities, some plots that were once cultivated are now grazed or used for mowing hay on spontaneous vegetation. All those production systems are mechanized and don't mow hay on karst plateau anymore. Small trees, bushes are encroaching grasslands nearby forested areas so as wet and remote areas of the poljes are left abandoned – it cannot be mown mechanically, and there are not enough animals grazing them. Plots close to the villages, from neighbours who aren't here, are used for grazing and mowing instead of polje bottoms. Benchlands become grasslands for grazing, and some wet polje bottoms turn into forests (Figure 60).

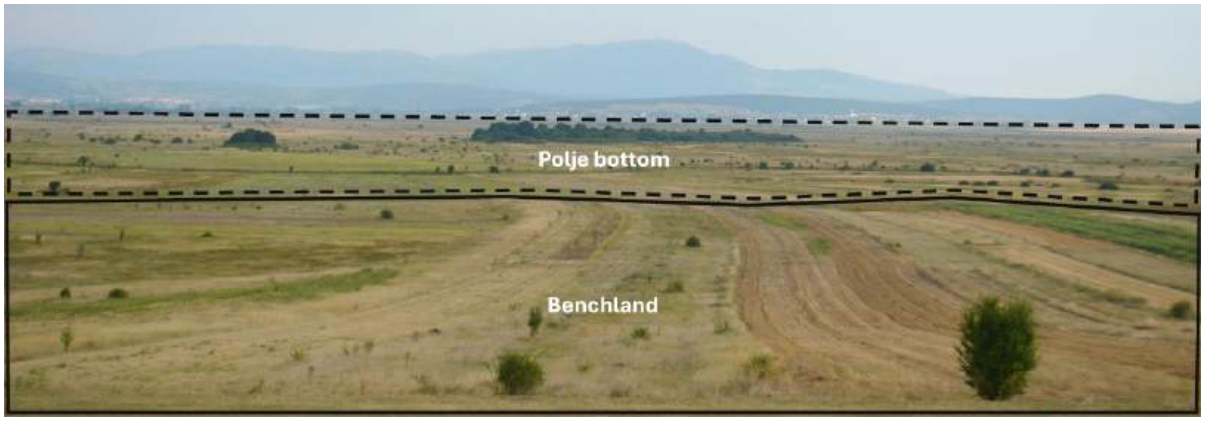


Figure 60: Example of polje bottom encroachment on Livanjsko polje, Prisap. Anouk Fraisse.

Farmers sow in priority on their private lands. When they don't have enough surfaces, they use some extra lands from neighbours who are not using theirs anymore (because they never came back after the war or because they work in other sectors). They do it in exchange for money or services. Natural grasslands are mowed for hay production on private lands. On neighbour's ones, it is perceived as a service and as a way of maintaining the landscape open. Thus, farmers don't need to pay for it, they only have (oral) agreements (Figure 61).

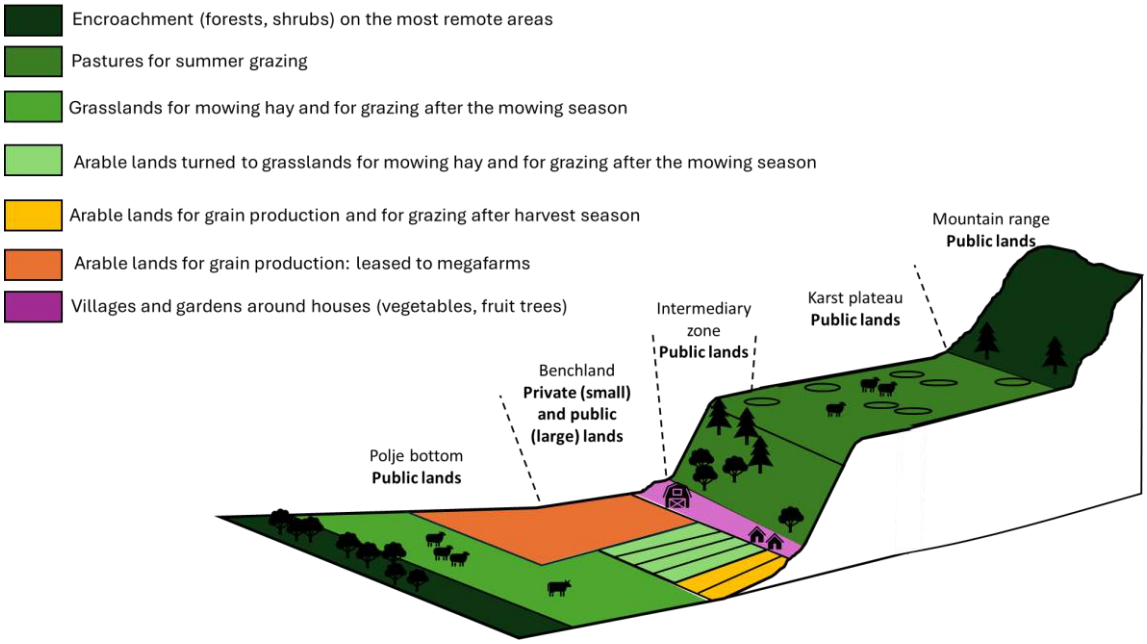


Figure 61: Landscape units belonging and usage by the current production systems. Emmanuel Artis and Anouk Fraisse.

On the densest area, the repartition of farms can be illustrated as in Figure 62.

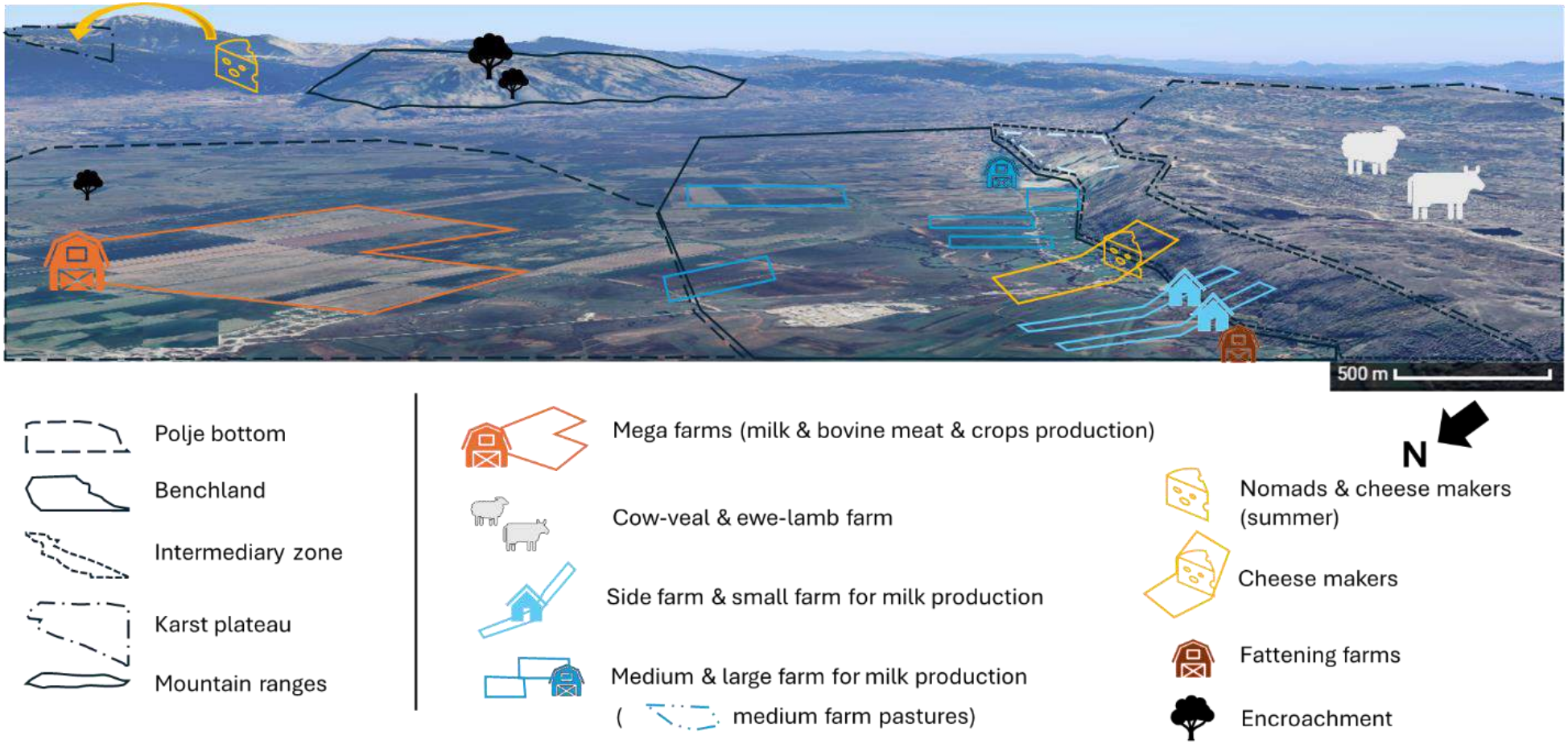


Figure 62: Spatial repartition of farming systems on the study area. Example in the municipality of Tomislavgrad. Emmanuel Artus & Anouk Fraisse.

Part IV: Diversity of production systems in the study area

Among the 15 types we observed (Figure 57), we realized 6 models. As nomadic systems are coming to an end, it was no use for this study to go more into details. For milk production systems, we decided not to create models for large farms for milk production as the main difference with megafarms for milk production is the size of the plots, other practices being similar. The main variation between small family farms and side farms is the time spent on the farm; equipment and practices are the same. We chose to build a model for side-farming systems (S), as they are more numerous. It has not been possible to meet the owners of megafarms for cow-veal, so we only analysed cow-veal farms. Ewe-lamb systems emerged from a different dynamic than cow-veal systems, that's why we studied them more precisely. Fattening systems are less anchored than other systems on the use of the landscape units. As they only represent 15 farms on the study area, we left them aside. The owner of the megafarm for crop production was not willing to discuss, thus we have no model for it.

1. Side-farming systems (S)

Side farmers are mostly pensioners having an agricultural activity aside their pension. Some have some crops (potatoes or cereals), mow some hay or raise a few animals. Most of them raise dairy cows (Simmental) and sell their milk to the local dairies. They represent the most widespread type of farm in the study area: around 70% of the number of farms (and 30% of the milk production). We chose to focus on them, and we relied on 6 interviews for creating this model.

On the benchlands, cereals are grown on farmers' own private lands and hay is mowed on the private lands their neighbours entrusted them. These farmers raise from 2 to 7 dairy cows (Simmental breed). They are kept in a stable in winter – often on the ground floor of the farmer's houses. In summer, they first have access to a plot of fenced pastures, adjoining the stable. Then they can graze the polje bottom for aftermath, entrusted to the main farmer of the village already bringing his cows there. This farmer belongs to the model *Small family farms for Milk production*. This organization is at the village scale, animals coming back every evening for milking time (Figure 63).

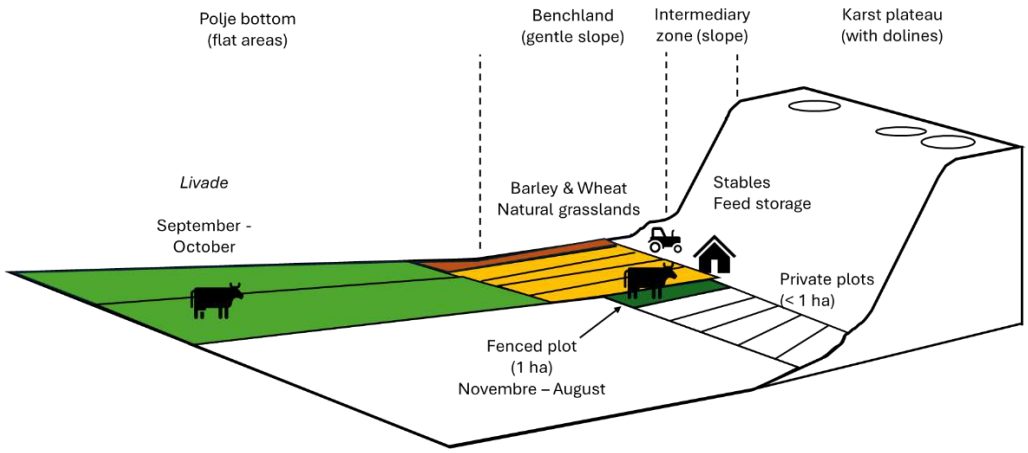


Figure 63: S - Landscape units used. Emmanuel Artus and Anouk Fraisse.

At the village scale, farmers also share some equipment which is not often used (manure spreader, rotary discs for tilling, trucks for transporting hay bales). Each farmer possesses all the

machinery necessary from mowing to baling hay. Equipment is rather old (from Yugoslav time for the tractors) and fixed for as long as possible. These farmers require seeds, fertilizers and energy for their functioning (Figure 64).

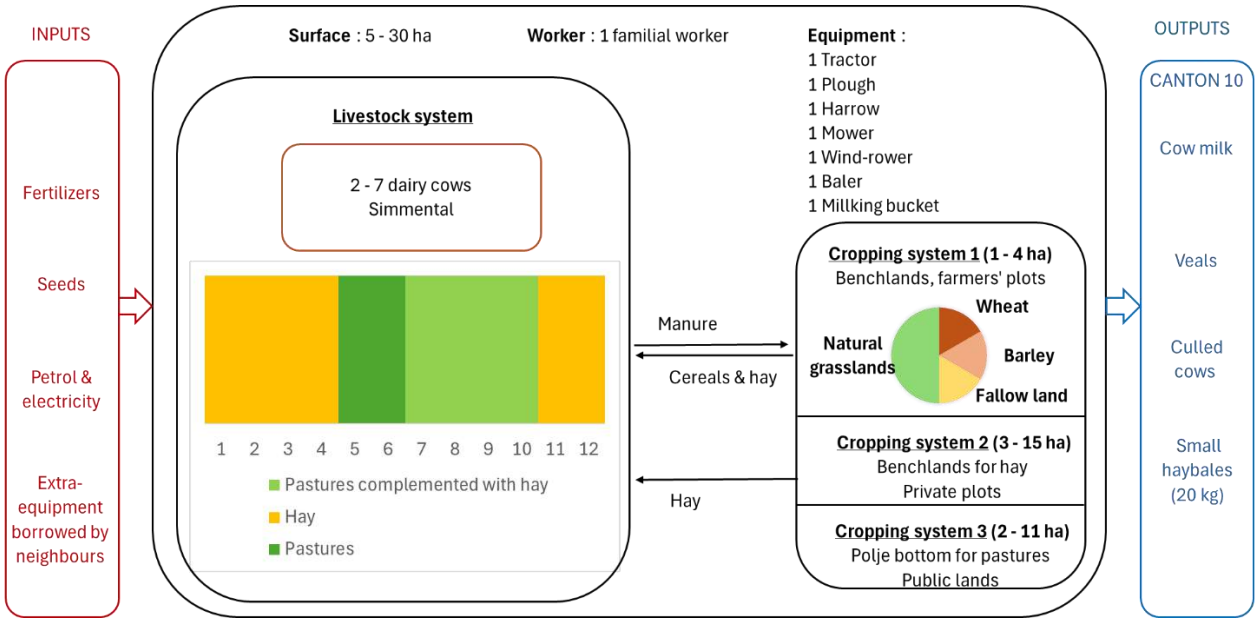


Figure 64: S – Global functioning of the production system. Emmanuel Artus and Anouk Fraisse.

Cropping systems

This type of farm produces all the feed needed for the animals. The land use is split into 3 cropping systems (Figure 6565).

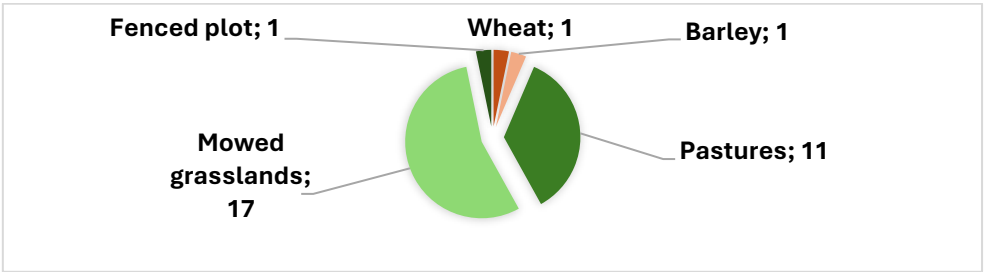


Figure 65: S - Land uses, example for a farm with 20 ha. Emmanuel Artus and Anouk Fraisse.

The rotation of the first cropping system *(1)* includes 2 years of crops – wheat and barley – and 4 years of fallow land which turn naturally into grassland. They are yearly mown except for the first year. The 4 years of fallow land are possible thanks to the availability of neighbours' lands.

(1) wheat // barley // fallow land // grassland // grassland // grassland

Ploughing is done in autumn, so as tilling and sowing of wheat. The plot for barley is tilled and sown in spring. Farmers spread the manure from the barn and add about 200 kg/ha of fertilizer. Ploughing is systematically done before sowing cereals, to destroy the grassland the first year and to deal with weeds the second year. Tilling is done with a harrow or discs, depending on soil properties. Bought seeds are sown with a drill. Harvesting is done in August by a contractor. These farms have yields about 3.5 t/ha for wheat and 3 t/ha for barley.

The second cropping system is composed of the grasslands exclusively used for hay (not part of a rotation). They are fertilized with the rest of the manure. Farmers mow them once a year. Located

on the benchlands, the yields are about 4 t/ha of hay (fresh matter). Aftermaths are grown with the summer rain and the vegetation regrowth.

The public pastures in the polje bottom are the 3rd cropping system. It is only used for grazing, without any fertilization. The number of hectares is estimated thanks to *Medium family farms for* Milk production.

Livestock system

Those farms don't have their own bull, they borrow for free the one of neighbouring bigger farms from type *Small family farms for Milk production*. Calvings are spread all over the year. The turnover of the herd is around 20%. It means that, for a farm of 5 cows, 1 female calf would be kept each year (Figure 66). This calf would be fed with its mother's milk for 3 or 4 months. The other calves are fed with their mother's milk for a few days (usually 5 days), until they are sold. Most of them are sold to Republika Srpska (in Gradiška) for further fattening. Apart from the cow with its calf, the cows are milked everyday twice a day for a period of 10 months, and they are dry for 2 months. They receive compulsory vaccines according to Federal rules, and antiparasitic (twice a year), before and after summer grazing.

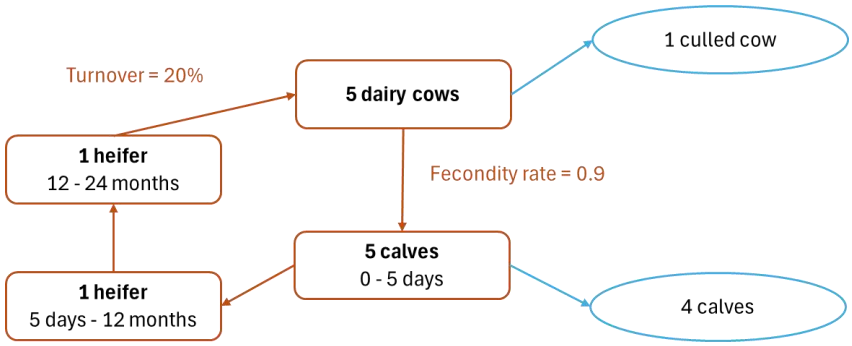


Figure 66: S - Herd management, example for a farm with 5 dairy cows. Emmanuel Artus and Anouk Fraisse.

Animal feeding

From November to April, cows are tied in stable, fed with hay and cereals. During the mowing season, they pasture the private fenced plot. However, it is not enough to feed them for whole period. The precipitations along with the karst substrate don't allow the grass to be green for the whole summer. Farmers complement them with hay/grass as soon as the 7th month (Figure 67). After mowing season, during 9th and 10th months, the cows are entrusted to the village shepherd/farmer for pasturing the polje. The cost is about 40 KM per month and per cow.

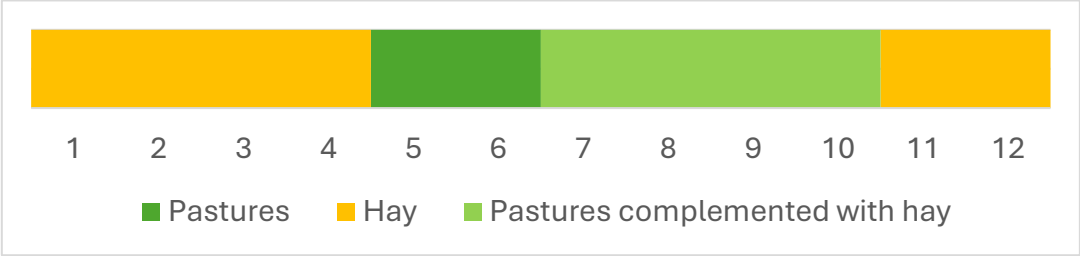


Figure 67: S – Origin of the cows feed, per month. Emmanuel Artus and Anouk Fraisse.

Quantities of feed are given in Table 5. Being only fed with hay and some cereals, milk production is about 2 100 L/cow/year. It is the lowest milk production per cow of the study area.

Table 5: S - Feed quantities (kg DM/day/cow). Emmanuel Artus and Anouk Fraisse.

	Pasture	Hay	Cereals
November-April	0	22	3
May-June	unlimited	4.5	3
July-August	unlimited	17.5	3
September-October	unlimited	8.5	3

Working calendar

Mowing hay is the most labour-intensive activity of the year. It requires such an amount of work that farmers rely on some family help to do it, especially the mowing and transporting of square bales around 20 kg (Figure 68). This help is only available from mid-July to mid-August, with a high activity during these weeks. Small bales require more time for baling than round-balers, as well as for loading and unloading the bales (by hand) on the trailer. Commuting between the plots and the farm is also time consuming, as several back-and-forth are needed to carry all the bales. Farmers still use small balers because round bales are not adapted to their stables and round balers are expensive, it would require a tractor fork and new buildings for storing bales. The rest of the year, the main constraint is to milk the animals twice a day with a milking pot. With the feeding of the animal and the cleaning of the small stable, it is doable for one farmer alone.

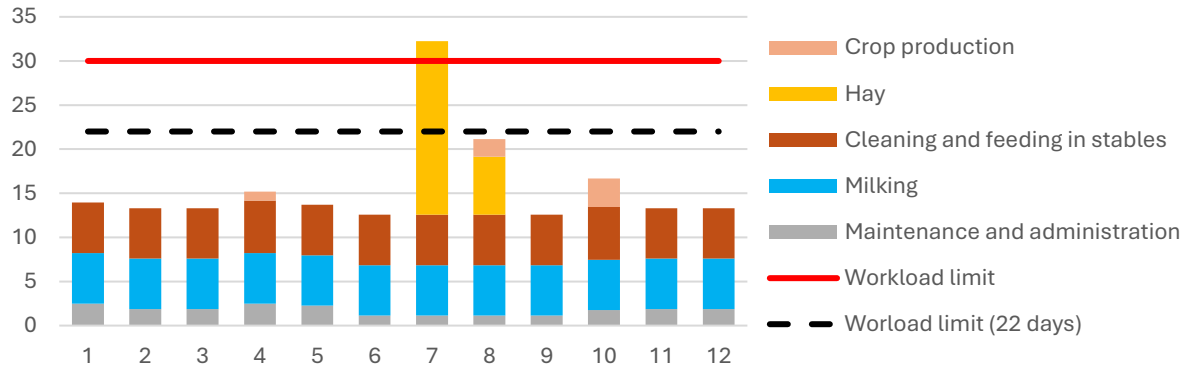


Figure 68: S – Working calendar, example for a farm with 5 dairy cows. Emmanuel Artus and Anouk Fraisse.

2. Small family farms for Milk production (M-S)

This type of farm is based on 3 interviews. Unlike for side farming systems, these farmers have no other income out of agriculture. They are also present all over the study area but have more animals for a more decent income. *"Under 10 dairy cows, it is impossible to live out of agriculture"* (H-Tom-06). They also have all the implements for mowing and growing crops not to rely on anyone else except a contractor for harvesting cereals. As these farmers need more cereals than side-farmers for their animals, all their private lands are used for growing crops and fallow lands are removed from the rotation (Figure 69).

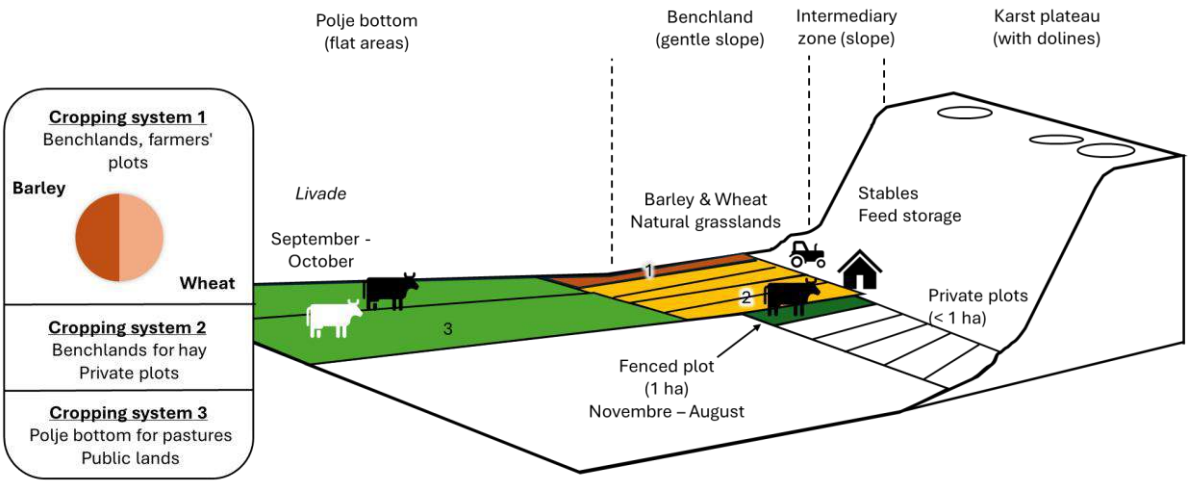


Figure 69: M-S - Landscape units used. Emmanuel Artus and Anouk Fraisse.

The feeding of the animals is slightly different from side farming systems. In May and June, cows graze the intermediary zone around the house, shepherded by the farmer. During mowing and harvesting period, cows are mostly fed with hay and taken to pastures whenever it is not possible to do hay. In September and October, farmer look after their cows on polje bottoms – and on karst plateaus for goats. For those 2 months, they are also paid to take the cows from side-farming systems with their own animals (in white on Figure 69). The cows are complemented with cereals all year round (about 3 kg/cow/day). All the plots for grains and hay are located on benchlands.

3. Medium family farms for Milk production (M-M)

The medium family farms for milk production started to appear around 2010, in bigger families (than S-M and S). As they are bigger, they can produce more hay, more animals and buy more equipment. Farmers are equipped with 3 tractors: often 2 old ones inherited from relatives or bought several years ago and a recent one of around 100 hp (the biggest of the farm). Most of the implement for these tractors is bought second-hand from European market. Their larger number of animals enabled farmers to invest in equipment for round-bales, haylage (wrapper) and silage (corn drill and harvester).

Indeed, the main difference with small family farms (M-S) is that farmers produce haylage and/or silage to feed their animals in winter. It enables them to have even more animals (between 20 and 40 Simmental cows), and more milk produced per cow. The crops are grown on private plots, on benchlands, close to the farm (Figure 70). As farmers don't own enough surfaces for growing crops, they lease land from their neighbours and relatives. Indeed, farmers usually don't have more than 8 ha in private property. They still rely on pastures for the summer feeding: the cows stay around the villages, on the intermediary zones. Just as in small farms, they're taken to polje bottoms after mowing season (Figure 70).

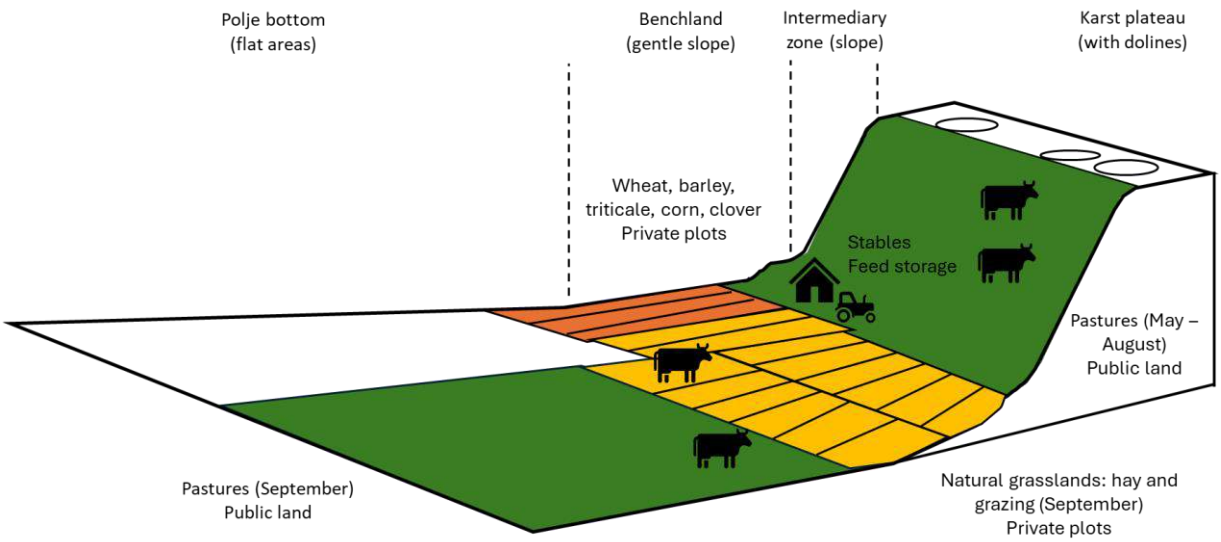


Figure 70: M-M – Landscape units used. Emmanuel Artus and Anouk Fraisse.

They are mainly located in Kupres and Tomislavgrad. The possibly to grow corn varies from one location to another. Corn for silage is more likely to be grown in Livanjsko polje (701 m asl) and Duvanjsko polje (865 m asl) whereas natural grasslands or improved grasslands for haylage are more likely to be found in Kupreško polje (1115 m asl). This is explained by a shorter summer period when the elevation is higher. Cold temperatures strike sooner and corn yields are not ensured. As this type of farm rely on the feeding to achieve its milk production, such a risk cannot be taken (whereas it can for meat production systems based on corn silage, which were observed in Kupres).

Moreover, these farms were registered as legal persons (and not physical persons as the smaller farms), which allowed them to have bigger amounts of money for the different types of subsidies. It also enables them to be subsidised for purchasing new equipment, as powerful tractors.

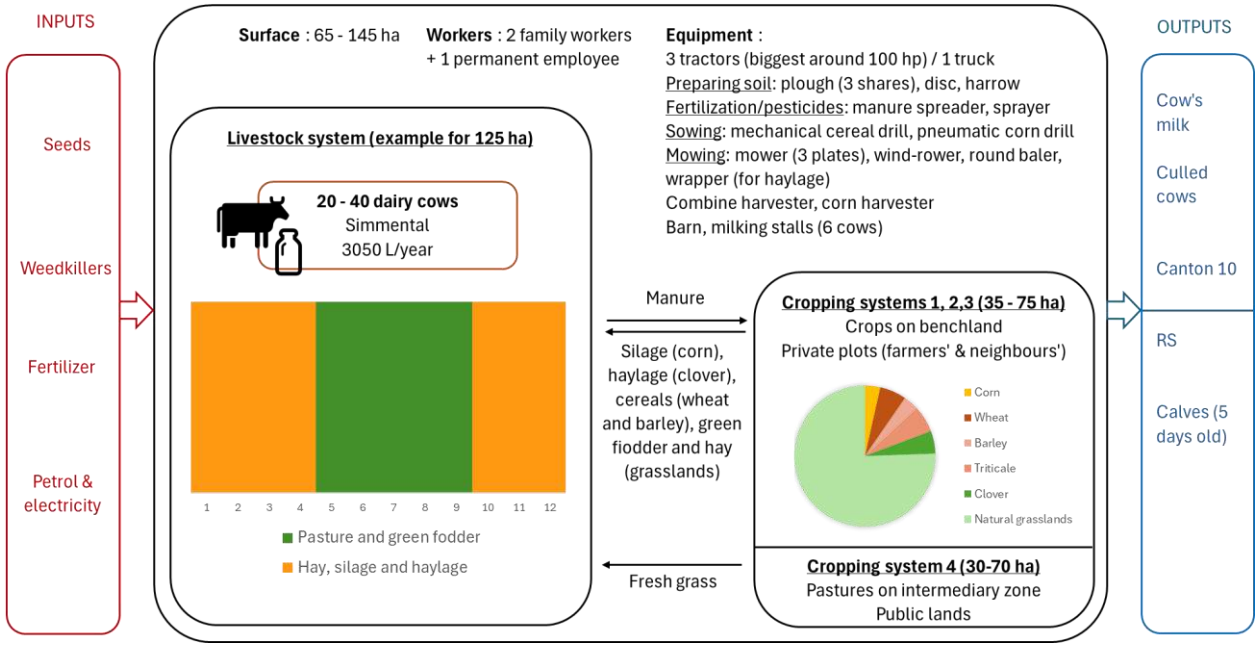


Figure 71 M-M – Global functioning of the production system. Emmanuel Artus and Anouk Fraisse.

Cropping systems

In this type of farm, farmers grow wheat, barley and triticale for grains and mow natural grasslands for hay (Figure 71), as in the smaller farms (side-farms and small family farms). The difference is that they also grow corn for silage and clover (or alfalfa) for haylage. All crops follow a 6-year rotation: 2 years of cereals (wheat, triticale, barley or corn) and 4 years of grasslands (clover or fallow). This rotation is allowed by the lease of extra land; without them, farmers would have to follow the same rotation as in the small family farms for milk production.

(1) Wheat // Triticale // Clover // Clover // Clover // Clover

(2) Wheat // Triticale // Fallow // Natural grassland // Natural grassland // Natural grassland

(3) *Corn // Barley // Fallow // Natural grassland // Natural grassland // Natural grassland*

As in the smaller farms, wheat and triticale are sowed in autumn and barley in spring. Corn is also sowed in spring. Farmers also spread their animals' manure of the crops, but they spray bigger amounts of fertilizers: 300 kg/ha for corn and 250 kg/ha for all other crops. Weedkillers are used one month after sowing, when crops have started to grow. Thus, yields are higher than in small family farms: 4 t/ha for wheat and triticale, 3,5 t/ha for barley. Corn silage yields are around 20 t/ha and clover haylage around 20 t/ha.

Livestock system

The herd management is the same as in side-farms, only with a bigger number of cows (Figure 72). The only difference is that, here, farmers have their own bull, renewed every for 4 years. One is bought every 4 years, and one is raised and exchanged every 4 years, to maintain the genetic health of the herd. In some farms, all the female calves are kept up to 2 months and are then sorted out between the ones that will be kept and the ones that will be sold. It enables farmers to have a selection based on the morphology of the calves besides considering the milk production of their mothers.

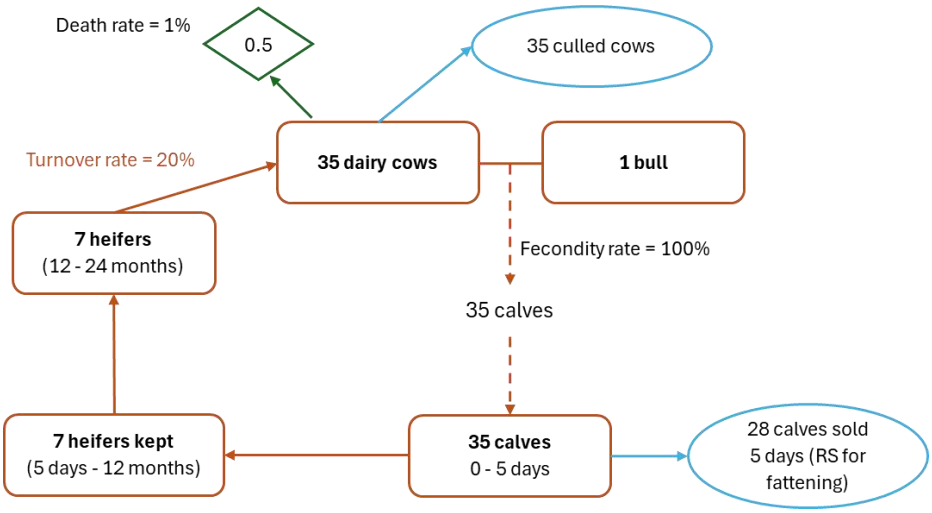


Figure 72: M-M – Herd management, example with 35 dairy cows. Emmanuel Artus & Anouk Fraisse.

Animal feeding

The feeding of the animals in this type of farm is completely different from the smaller farms. It relies on pastures completed with fresh grass and grains in summer; and on hay, silage, haylage and grains in winter (Figure 71).

The cows are taken outside from the 1st of May until the end of September. As for everybody farms in the study area, from May to August (mowing season), the cows aren't allowed on benchlands and polje bottoms. An electrical fence is set to prevent the cows from going ruining the harvests. They freely graze in the intermediary zones, above the farms. When mowing season is over, the

electrical fence is removed, and cows graze grass regrowth on benchlands and polje bottoms. As the grass on the intermediary zone is low (and of lesser quality than the one growing on the polje kept for hay production), cows are complemented with green fodder and cereals. Green fodder is harvested by hand, with a scythe, on the closest plots to the farm. It is distributed twice a day during the milkings, along with cereals (Table 6).

During wintertime, the cows are fed with hay, silage and haylage (Table 6). Silage and haylage represent 50% of the feed distributed to the animals. To replace green fodder (which doesn't grow in winter), a bigger quantity of cereals is given twice a day during the milkings.

Table 6:M-M – Ration of the cows (in kg/day/cow). Emmanuel Artus and Anouk Fraisse.

Winter ration	Hay (natural grasslands)	20
	Haylage (clover)	10
	Silage (corn)	10
	Cereals (wheat, barley, triticale)	5
Summer ration	Pastures	at will
	Green fodder (wheat, triticale)	5,6
	Cereals (wheat, barley, triticale)	1,5

This feeding enables a better milk production per cow, especially in winter, compared to cows fed only with hay during wintertime. Farmers saw a difference between before and after they've started using haylage and silage. The cows produce an average of 3 050 L/cow/year. As they produce more milk than smaller farms, these farms can better negotiate the price they sell their milk to the dairies – around 0,85 KM/L (against 0,75 - 0,80 KM/L for side farmers and small family farms).

"[equipment for silage/haylage] is expensive but it's worth the investment… there is more milk in wintertime! It's at least 40% more milk!" (T-Kup-14).

The cows that are not milked (not in their lactation period) are fed the same as the milked cows (pastures in summer and hay, silage, haylage in winter) but they don't receive green fodder nor cereals.

Working schedule

The difference with side-faming is that farmers don't have any other source of income. Agriculture is their full-time activity.

The basis of the work is milking the cows, cleaning the stable and the milking stall, mulching the stable and feeding the animals (giving them hay in winter and checking the pastures in summer). It can be managed by the 2 family workers, if they work more than 22 days per week – which is the case for all standard jobs (black line and light red line on Figure 73). Indeed, full-time farmers are more likely to work 30 days per month than 22. The most-labour intensive period of the year is still the mowing season, and it cannot be done only by the family workers. One permanent employee is hired (dark red line on Figure 73).

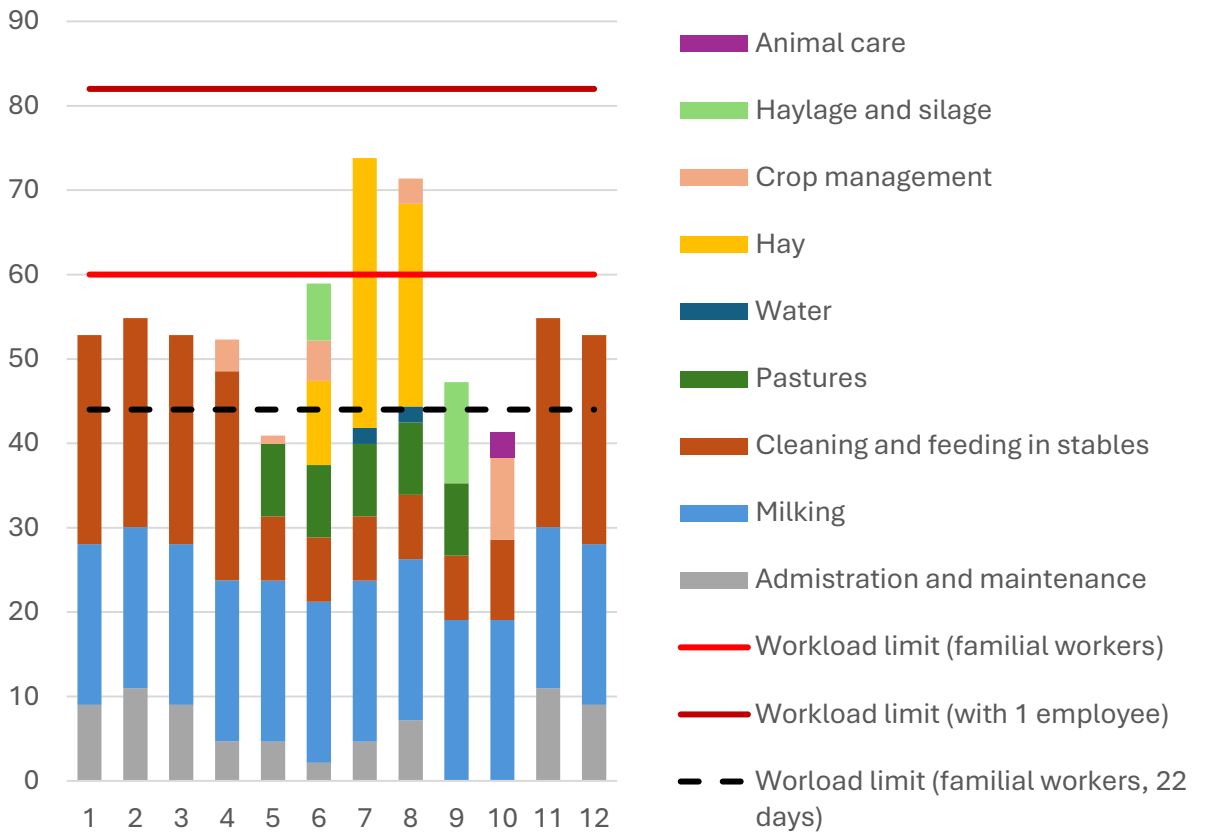


Figure 73: M-M – Working calendar, example for 35 dairy cows. Emmanuel Artus & Anouk Fraisse.

Improved grasslands (clover or alfalfa) are mowed in spring for making haylage (light green on Figure 73). Hay is mowed in July and August. Wheat, barley and triticale are harvested in August, at the latest at the beginning of September (light orange on Figure 73). Corn is harvested right afterwards (light green on Figure 73), and before the preparation of soil for the plots of wheat and triticale begins in October. The tasks related to improved grasslands (clover or alfalfa) for haylage and corn for silage happen out of the most labour-intensive period (i.e. mowing hay). It enables the production of more animal feed. Thus, the number of cows can be increased (as well as the milk production per cow). It is the main difference between families having 15 cows, only relying on hay and those having 35 cows, relying both on hay and silage/haylage.

4. Large farms for cow's Milk production (M-L)

In Tomislavgrad, where corn silage yields are ensured, even bigger farms than the medium family farms developed in the last years. The elevation and the local climate of Tomislavgrad are more suitable for large scale corn production. The main difference with medium family farms is that in those large-scale farms, the cows are fed with corn silage all year round. They are always kept in stable. These farms represent around 2% of the number of dairy cow farms in the study area; however, they represent 35% of the cow's milk production.

As their animals produce a lot of milk (around 8 000 L/cow/year), they are able to negotiate higher prices for their milk with the big local dairies (than medium family farms). After the labelling of the PGI *Livanjski sir*, some of the farmers saw an opportunity in creating a farmer's association to negotiate even higher prices for their milk. They are able to sell it up to 0,90 KM/L.

"We will request support as an association of 10 large milk producers from the municipality, asking [the local dairy] better prices." (H-Tom-07)

The description of these large farms for cow's milk production is based on 3 interviews. As they are quite new in the area, they still haven't reached their "final size". Each of the interviewees talked about 300 dairy cows in a few years – and they currently have around 150 dairy cows. However, farmers lease private plots to grow the feed needed for their animals. It means that they rely on small plots (less than 1 ha), fragmented in the landscape and sometimes far from the farm buildings (Figure 74). It is the main factor limiting their production and the expansion of their farms. Indeed, lands are not often sold, even if they are unused.

"It's on a 10 km radius... Nobody wants to sell and it is spread all over the place!" (H-Tom-07)

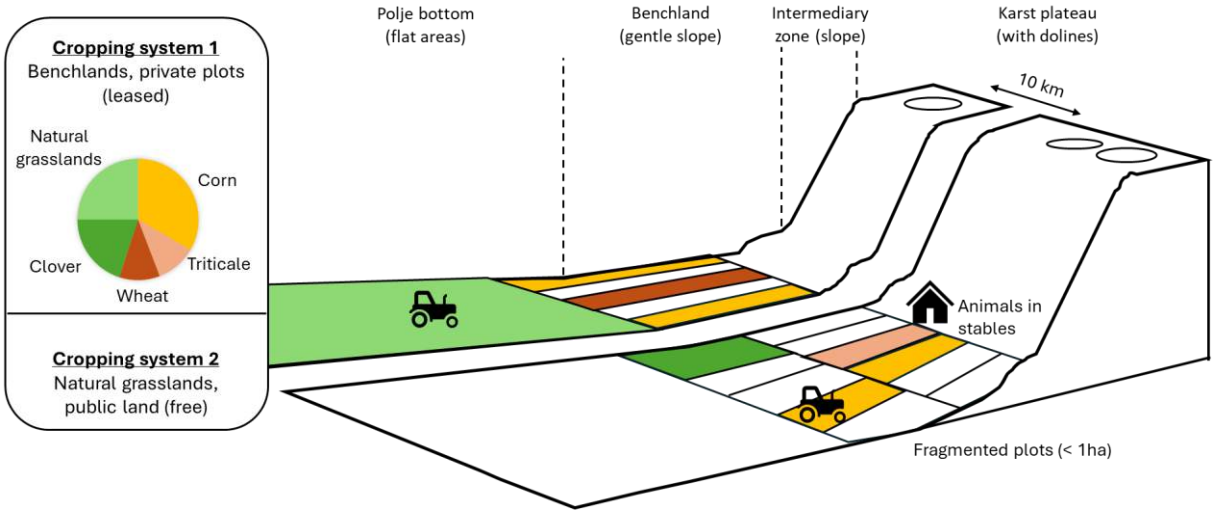


Figure 74: M-L Global functioning of the production system. Emmanuel Artus and Anouk Fraisse.

5. Megafarm for cow Milk production (M-XL)

Also in Tomislavgrad (where corn silage yields are ensured), the biggest cow's milk production farm of BiH can be found. It is part of a bigger complex: there is also one company in Glamoč (for veal fattening) and one in Posušje (for veal, pig, and lamb fattening). Exchanges of animals and feed are made between all 3 operations. We chose to focus on the milk production farm, as it is the production of highest interest to our study.

As large-scale farms, the cows are always kept in stables and fed mainly with corn silage. The difference is that this farm only use the plots of former State farms (both in Glamoč and Tomislavgrad), which are about 22 ha each – against less than 1 ha for private plots (Figure 75). Thus, megafarms can raise more animals than large-scale farms using private plots: between 380 and 570 dairy cows (Figure 76). These plots are located on the benchland and the polje bottom. Indeed, crops are grown on the areas that benefitted from the channelling of waterways carried during Yugoslavia.

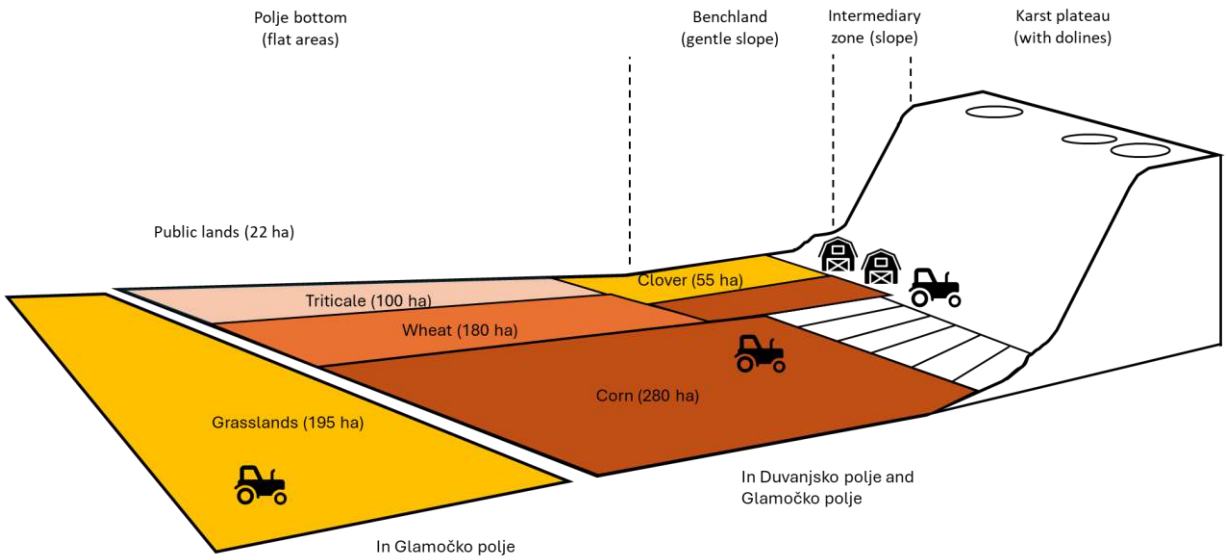


Figure 75: M-XL – Landscape units used. Emmanuel Artus and Anouk Fraisse.

The size of the plot allows modern and large equipment: 6-shares ploughs, 6-rows silage harvesters and tractor-trailers (Figure 76). New powerful tractors and machineries are regularly bought. For economic purposes, contractors are hired for combine-harvesters. Modern equipment is also used for livestock management: hay and silage distribution are mechanized, half the stables are equipped with automated scrappers, and the milking parlour is monitored with electronic collars (thanks to a 230 000 KM funding in 2021 from GIZ). As a new diversification, a power plant for processing manure is currently being built. It represents an investment of 2,5 million KM and it will produce around 300 kWh of electricity.

"We have the equipment on the farm, we hope it will be running by the end of the year... in any case, it will be operating on the following year" (H-Tom-05).

The owners of this farm lease around 80% of the public arable lands of the municipality of Tomislavgrad. The other 20% being leased to several farms (to large-scale farms and cow-veal systems). It means that no other state land is available; as private lands are too small to be economically viable for this production system and its equipment, its current size would be difficult to increase.

"The number of cows we have now is optimum for the land we possess [...] it's not economically viable to purchase more private land if it's not linked to the farm buildings, and private land is spread all over the polje" (H-Tom-05).

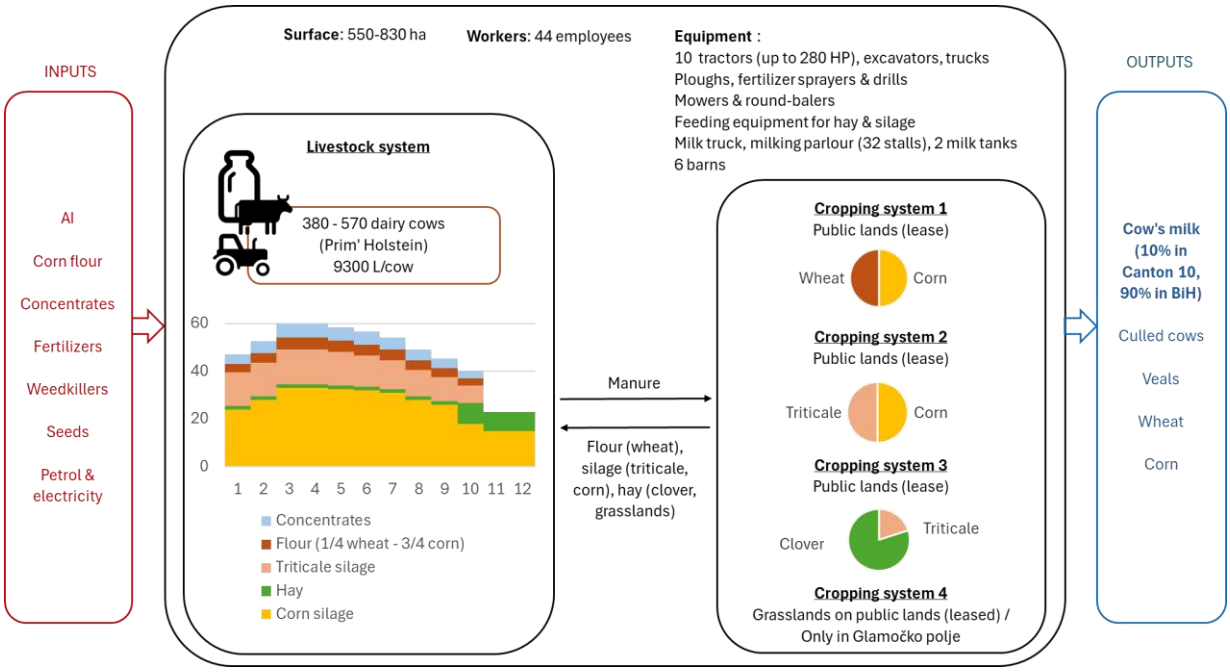


Figure 76: M-XL – Global functioning of the production system. Emmanuel Artus and Anouk Fraisse.

Cropping systems

Wheat is grown for grains, triticale and corn for silage and clover for hay. All these crops are grown both in Glamočko polje (on the benchland) and in Duvanjsko polje (on the benchland and the polje bottom). As Duvanjsko polje benefited from the channelling of the waterways, water is drained and it prevent crops from floods in the polje bottom. However, it is not the case in Glamočko polje, and it is less risky to grow crops on the benchland. Thus, the natural grasslands mowed for hay are all located on the polje bottom in Glamoč.

All the crops are managed in 4 rotations – or cropping systems (Figure 76). Corn is grown on 50% of the arable lands; it is followed by wheat or triticale. Clover is grown for 4 years and is preceded by triticale. Natural grasslands are not part of any rotation.

(1) Corn // Wheat
(2) Corn // Triticale
(3) Triticale // Clover // Clover // Clover // Clover on 14 ha

As for medium family farms, wheat and triticale are sown in autumn, corn is sowed in spring. Clover is also sowed in spring. Tilling is done before sowing, which is not the case in smaller farms.

The main difference with smaller farms is the fertilisation. Indeed, liquid manure from the cows (instead of manure for small farms) is spread right after tilling. NPK is spread in bigger quantities, before sowing: 400 kg/ha for corn, 350 kg/ha for wheat and triticale and 600 kg/ha for the first year of clover. Urea (around 125 kg/ha) – is added during the growing season of corn. Fertilization is adapted every 3 years according to soil analysis, carried out on samples from all over the farm. Weedkillers are also applied on corn, wheat and triticale at least once a year.

This crop management lead to the highest yields of the study area: 27 t/ha for corn silage, 26 t/ha for triticale silage, 5,7 t/ha for wheat (grains) and 5,3 t/ha for clover (hay). Most of the crop

production is used for the dairy cows feeding. The extra corn silage is sold locally whereas the extra wheat is exported, depending on market prices.

Livestock system
In megafarms, Prim' Holstein are raised (instead of Simmental for other farms).

Reproduction is managed with artificial insemination (AI) – bought from western Europe through the local veterinary services. In average, the success rate is around 95%. For the first calving of the heifers, the insemination is done with sexed AI, with a success rate of 60%. For the 40% left, a second insemination is done with classic AI. On the born calves, 70% are female ones. They are used for further selection and the herd turnover. All the following calvings are done with classic AI.

The turnover rate is higher than in smaller farms: 27% against 20 % (Figure 77). Indeed, as soon as the quality and quantity of the cows' milk decreases, they are culled (when they are 6 years old). Up to 3 months, the female calves kept are fed with their mothers' milk (they are milked, and the milk is distributed to the young ones). It represents 150 000 L/year. Apart from the heifers kept, all the other calves are directly separated from their mothers and sold within 5 days to the sister company in Posušje.

Moreover, one veterinary is at the farm every morning to check on health issues (blood samples are regularly analysed as well as milk samples). About 5 cows over the 560 are cured daily. These services are added to the yearly antiparasitic treatments and compulsory vaccines.

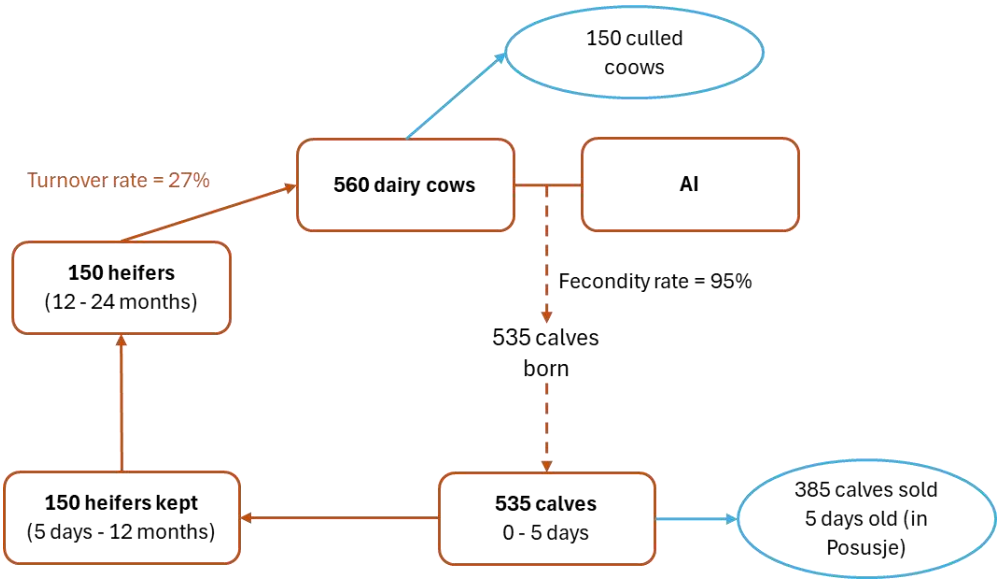


Figure 77: M-XL – Herd management, example with 560 dairy cows. Emmanuel Artus and Anouk Fraisse.

Animal feeding
Alike other milk production farms, most of the feed is produced on the farm. However, concentrates and corn flour are purchased. The feeding management is similar to the one in large-scale farm for milk production: it is dependent on the stage of lactation of the cows.

Indeed, the herd is divided into groups of 60 cows. Each flock has its own feeding, according to the results of milk analysis, carried out once a month for each cow. The ration thus changes every month (Figure 78). The aim is to fit approximately 30 indicators (such as proteins or vitamins rates) defined according to literature. Those indicators are established for 4 main periods: pre-lactation, lactation, post-lactation and dry period.

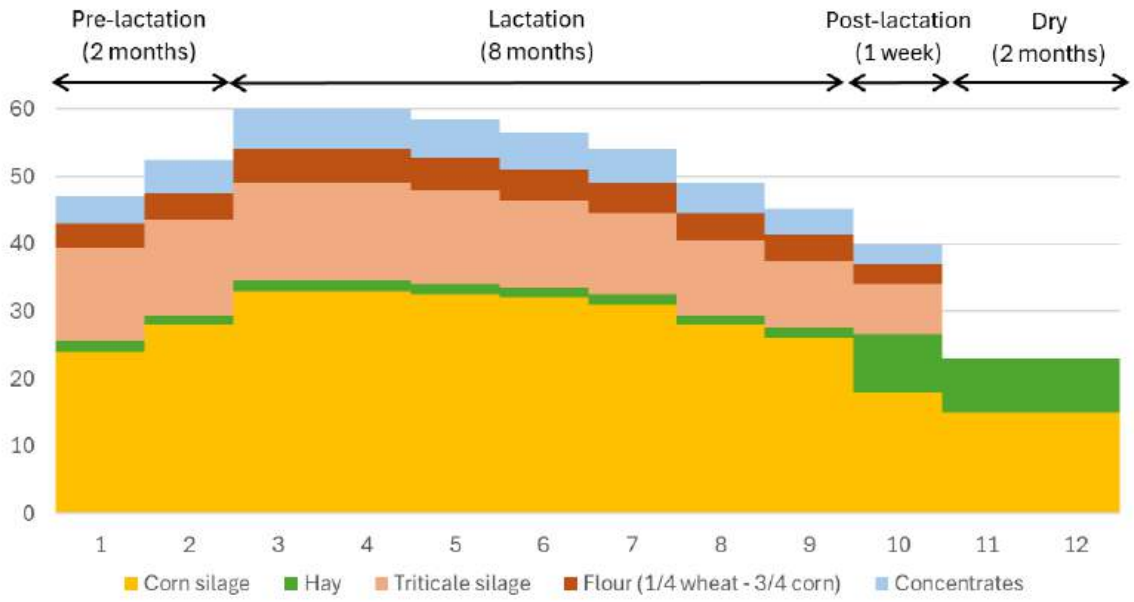


Figure 78: M-XL – Feeding calendar, adaptation of quantities per month (kg DM/cow/day). Emmanuel Artus and Anouk Fraisse.

The pre-lactation period corresponds to the beginning of the lactation period (before the production peak) and lasts for 2 months. The feed given is lower than the maximum capacity of ingestion of the cows, to avoid an overproduction that would lead to further health issues. During this period, the cows are milked 3 times a day and it starts 2 days after calving. The lactation period is divided into 3 sub-periods. The biggest quantity of feed distributed is reached in the firsts 2 months, then it is slowly decreased as the quantity of milk decreases. In this period, cows are also milked 3 times a day. The post-lactation period lasts for one week before the dry period. The cows are only fed with hay to ease the dry-off. During this period, they are only milked twice a day. During the dry period, the cows only eat corn silage and hay. Flour, concentrates and triticale silage are removed from the ration.

The heifers are fed with the same feed as the adult dairy cows, only the quantities are adapted to their needs and weight.

Thanks to this feeding and the breed, the cows reach an average milk production of 9 300 L/cow/year. The quantity of milk per cow and the big number of cows enable megafarms to negotiate the best prices for their milk with dairies: it goes up to 0,95 KM/L (0,85 KM/L for medium farms), including a premium for the deliveries they do themselves.

Working timetable

The main difference with the previous farms described is that in the owner of the farm doesn't work on it. He invests money in the operation and has employees on the farm. Indeed, there are 44 employees working and their work is divided into specific tasks: 3 workers oversee administration and manage the rest of the workers, 20 workers are dedicated to milking and feeding the cows, 1 to milk deliveries, 16 to crop production and 4 mechanics maintain equipment, stables and barns.

As in other farms, milking and feeding the cows is the basis of the work (Figure 79). As there are 3 milkings per day all year long, it requires many employees. Moreover, as the animals are always kept in stable and their feed adapted to their stage of lactation, the feeding management is also

time consuming. The adult cows are kept on flat-deck pen, the liquid manure as to be cleaned and brought to the storage place every few days. Mulching is only done in the stable of the heifers.

As very little hay is produced (in comparison with the crops), mowing season is not the most labour-intensive period of the year. It is the harvesting season (Figure 79). It is first done in Tomislavgrad and then in Glamoč, due to the different local climates. It starts with the harvest of triticale (for silage), before the summer temperatures hit. Then, wheat (for grains) is harvested. The last crop to be harvested is corn, at the beginning of the 10th month. On bad years, the last harvests can be postponed to the end of the 10th month. Clover is mowed in the 5th month (and a second time one month later), and the hay is mowed in the 7th month.

As wheat and triticale are sowed in autumn, it leaves a very narrow time-window for the soil preparation (after the corn is harvested). In average, employees have 15 days for spreading manure, applying chemical fertilizers, ploughing, tilling and sowing. The work must be well organized.

"one drives for harvesting corn and the other one goes right after for spreading manure before ploughing. This way, the sowing of wheat has never been postponed to spring" (H-Tom-05).

As megafarms produce high quantities of milk, they can afford delivering it. Moreover, the cost of the deliveries is included when they negotiate the prices for their milk. The milk is delivered to 18 times a month. Indeed, agreements are made with dairies (local or not) on a monthly basis. It means that the deliveries and contracts are renewed every month, to the highest bidder. Over the year, 90% of the milk is sold outside of Canton 10 and 10% goes to local dairies.

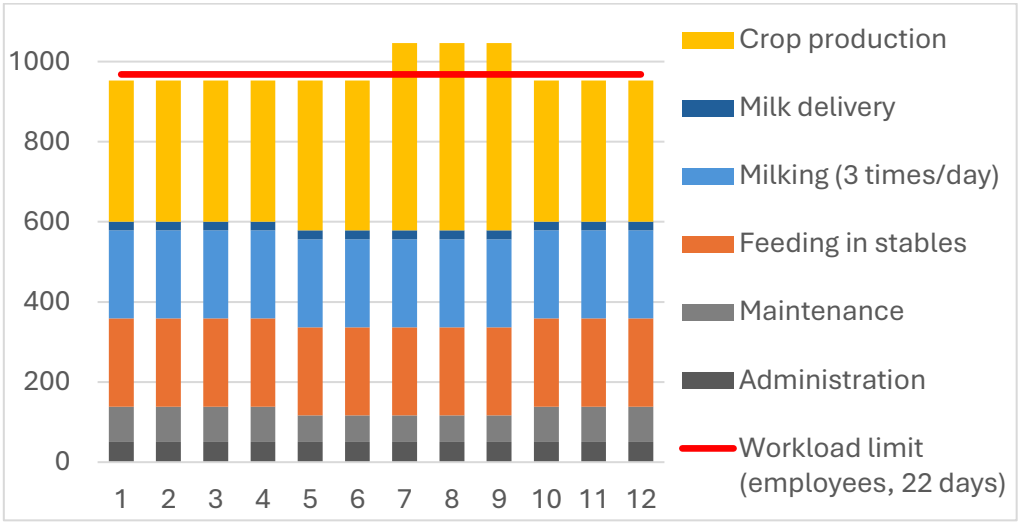


Figure 79: M-XL – Working calendar, example with 560 dairy cows. Emmanuel Artus and Anouk Fraisse.

6. Traditional cheese-making system for *Livanjski izvorni sir* (C)

In the wide diversity of home-made dairy products in study area, we chose to focus on *Livanjski izvorni sir* producers. We realized our model thanks to 8 interviews (mixing all types of producers). The *Livanjski izvorni sir* cheese makers are only present in Livno municipality – mainly in Grborezi, Komorani and Guber – as it is a condition for being part of the PDO association.

Cheese makers have the same number of cows as small farms for milk production (10 to 20 cows). They manage them the same way. They graze a small, fenced plot around the house during mowing season and are taken to polje bottoms afterwards (Figure 80). The main difference is that

cheese makers also manage a sheep herd. The sheep are taken to summer pastures on karst plateaus; and they're not coming back in the evening (Figure 80). Crops (barley and wheat) are grown on farmers' private plots on benchlands, close to the farm buildings. Hay is mowed on neighbours' or relatives' private plots (Figure 80).

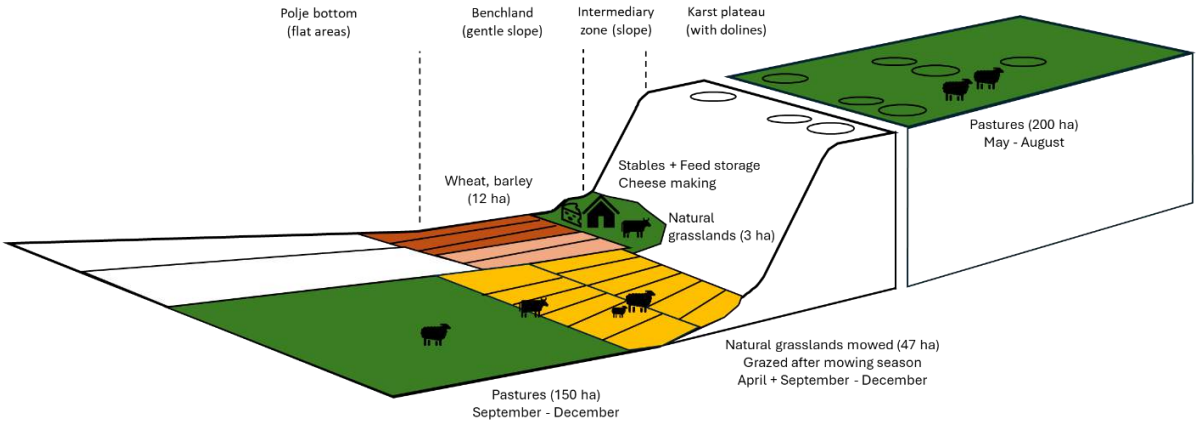


Figure 80: C – Landscape units used. Emmanuel Artus and Anouk Fraisse.

Half of the income of the cheese-makers is the sale of *Livanjski izvorni sir* in summer; the other half is the sale of lambs in May (Figure 82). In winter, they produce hard cheese made with 100% cow's milk. However, some farmers decided to sell their cow's milk to the local dairies to benefit from subsidies for milk production and avoid the workload of processing cheeses. We chose to keep those who are making cow's milk cheese in wintertime for our model.

On-farm cheese-making & commercialization

Those farmers inherited traditional and local know-how on cheese production and pasture management – as it is the case for all cheese producers in the study area.

From May to October, farmers produce *Livanjski izvorni sir* with raw milk. They use 70% sheep's milk and 30% cow's milk. They need around 7L of milk to make 1 kg of cheese. The production decreases slowly from the end of September and stops in October. In wintertime, farmers produce 100% cow's milk hard cheese. They need around 11L of milk to produce 1 kg of cheese. Ewes are not milked by then (Figure 81).

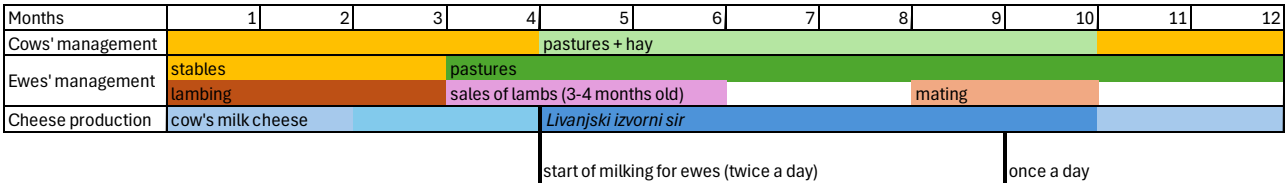


Figure 81:C – The 2 different cheese productions depending on the time of the year. Emmanuel Artus and Anouk Fraisse.

50% of the cheeses are sold on the farm: tourists, neighbours and acquaintances stop by to buy cheeses. The other 50% is sold through resellers, mainly in Canton 10. However, prices for cheese in BiH are quite low (in comparison with the work it requires). A significant proportion of *Livanjski izvorni sir* is smuggled through the border with Croatia for further sales in Dalmatia, where they can have better prices.

"Everybody is doing it" (T-Liv-09)
"Why do I have to sell illegally at the age of 70?" (H-Liv-014)

An idea that they've been offered is to make their cheese with pasteurized milk, as the local dairies do. However, they perceive pasteurisation as a loss of quality and taste.

"Pasteurized milk can be produced everywhere... raw milk is traditional milk, it can't be produced everywhere" (T-Liv-09)
"They told us how to pasteurize the milk, but it is not what we do, pasteurized milk is not our milk... they wanted to change traditional cheese" (H-Liv-016).

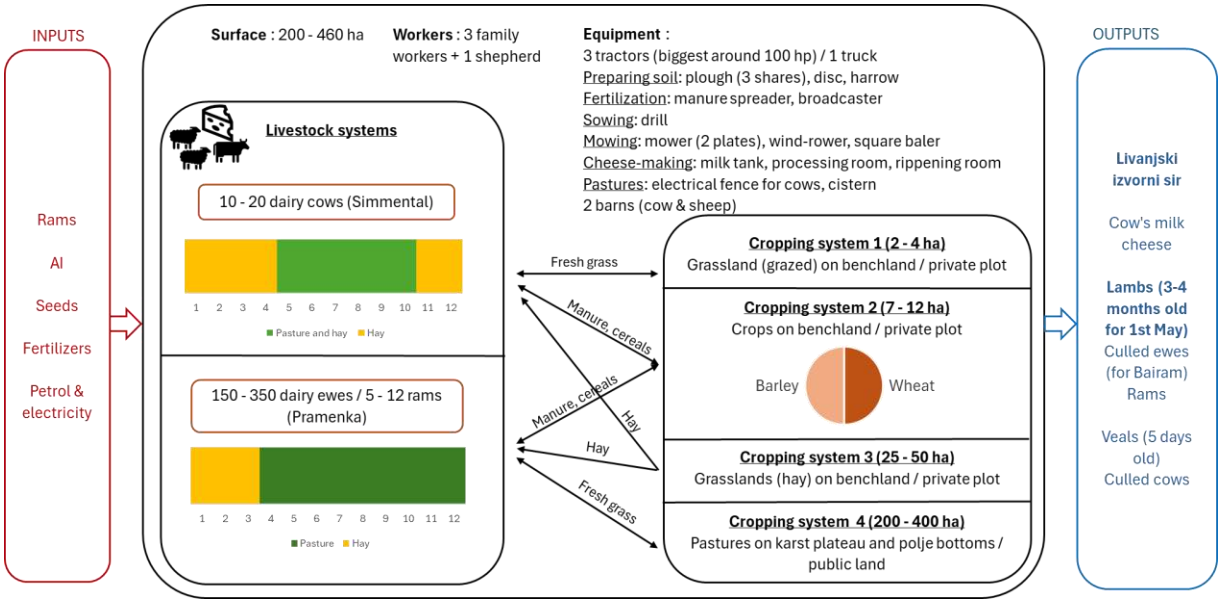


Figure 82: C – Global functioning of the production systems. Emmanuel Artus and Anouk Fraisse.

Cropping systems

The crops are managed the same way as in small farms for cow's milk production. Wheat and barley are part of the same rotation (cropping system 2 on Figure 82); wheat is sowed in autumn and barley in spring. NPK is added right before the sowing (250 kg/ha). To ensure yields, weedkillers are also used. Grasslands are mowed for hay production (cropping system 3 on Figure 82).

The main difference is that cheese makers use wide areas of pasture on public land (cropping system 4 on Figure 82). For people having around 300 sheep, 300 ha are used on karst plateaus (during mowing season). Around 50 ha are used on the polje bottoms (after mowing season) – in addition to the grass regrowth (on private plots), for both sheep and cows.

Livestock systems

The cow herd is managed the same way as in side-farms, only with a bigger number of animals. Reproduction is done with artificial through the local veterinary station – mainly Simmental breed. The turnover rate is around 20 % (Figure 83). The female kept are under their mothers for the first 3 months and the other calves are sold within the firsts few days, for further fattening in RS. The calvings are spread all year round. Culled cows are mainly sold within Canton 10.

The cows are kept around the farm and are treated against external and internal parasites only once a year.

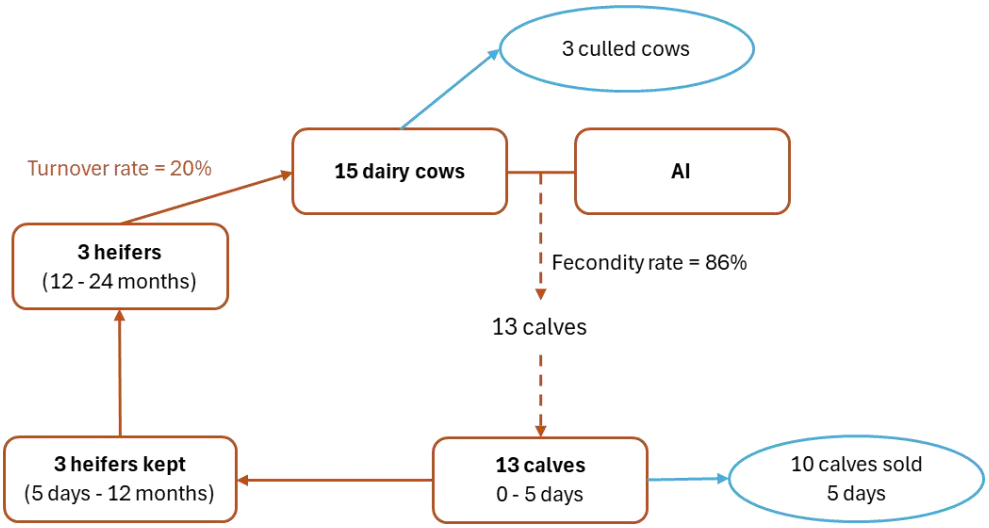


Figure 83: C – Cows herd management, example with 15 dairy cows. Emmanuel Artus and Anouk Fraisse.

The ewes are raised both for milk and lambs. Rams and ewes mate in September and October, when the ewes come back from the summer pastures. They are altogether for 2 months and the lambing happens between mid-January and mid-March, just before the ewes go back to the summer pastures.

The turnover is around 20% (Figure 84): for farmers raising 300 ewes, 60 female lambs would be kept each year. The turnover of the rams is higher, around 30%. They are raised and then exchanged with rams from neighbours; to avoid consanguinity (they mate for the first time at 1 year old). In average, farmers need 1 ram for 30 ewes. The other lambs are kept under their mothers for 3 or 4 months and sold for the 1st of May, an important national holiday in BiH. The lambs not sold for the 1st of May are also sold to Muslim population for Bairam celebration. The lambs are mainly sold in Canton 10. There is a 10% mortality for lambs due to twin births where one of the lambs is stronger than the other and gets more milk from the mother. Farmers consider that it is *"not so much"* (T-Liv-11).

After the lambs are sold, the ewes are milked (from May until October). *Livanjski izvorni sir* is produced during this period. They are milked twice a day except in October, when they are milked once a day, because their milk production decreases.

The culled ewes are sold outside of Canton 10, for Bairam when they are around 7 years old. The old rams are also sold for the same celebration when they are 4 years old. People seek their horns, and they can be sold at better prices than the ewes. Over the year, 3% of the adults are lost, the majority being in the pastures.

All the sheep are treated against external and internal parasites twice a year – before and after summer pastures.

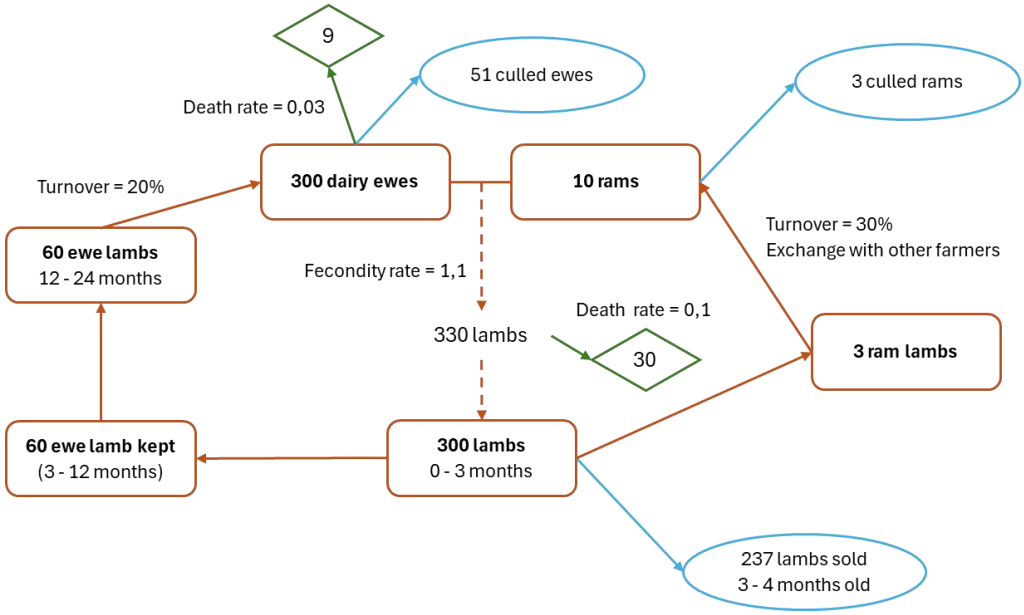


Figure 84:1 C – Ewes herd management, example with 300 ewes. Emmanuel Artus and Anouk Fraisse.

Animal feeding

The feeding of the cows is the same as in small farms (Table 7). Cows are fed with hay and cereals during wintertime. Starting in May, they have access to 3 ha of fenced pasture around the farm. Farmers also give them some hay, to ensure a good milk production. In the middle of summer, the grass is dry and the 3 ha are not enough to cover the animal needs; more hay is distributed. After the September rains, the cows eat grass regrowth on the benchlands and the amount of hay is reduced. When farmers have some time available, they also take the cows to graze in the polje bottom. Traditionally, they were taken to the intermediary zone for summer pastures. However, farmers are kept busy with the milkings and cheese-processing and cannot take them outside. Farmers prioritize summer pastures for ewes as their milk represents 70% of the milk needed to make *Livanjski izvorni sir*. The lack of shepherds also explains that cows stay around the farm.

"No shepherd... so no grazing" (H-Liv-014)

Table 7: C – Feed distributed to the cows (kg/day/cow). Emmanuel Artus and Anouk Fraisse.

Winter ration: January – April	Hay (natural grasslands) Cereals (wheat, barley)	24 4,5
Spring ration: May – June	Pastures Hay (natural grasslands) Cereals (wheat, barley)	*3 ha (enough for 2 months)* 5 4
Spring ration: July – August	Pastures Hay (natural grasslands) Cereals (wheat, barley)	*3 ha (dry in summer)* 12 4
Automn ration	Pastures Hay (natural grasslands) Cereals (wheat, barley)	*3 ha (regrowth after August rains)* 8 4

The sheep are in stable from January to March and they are fed with hay and cereals (Table 8). The quantity of cereals is bigger for the lambing period (January and February) and decreases in March. In April, they graze on the poljes (benchland and polje bottom). In May, they are taken to summer pastures located on the karst plateau around Livno, at the foothill of the Cincar (Krug, Borova Glava, Koričina). Indeed, the grass of the karst plateau is of better quality for cheese-making. There is a smaller amount of milk but it is richer whereas there is a bigger amount in the polje but less rich.

"Milk quality is of course better in the mountains!", "During mowing season, the grass is much taller than in the [plateau], greener, they eat too much and have health problems... At the foothill, it's better for sheep; it's a rocky area" (H-Gla-03)

Traditionally, people would also process the cheeses on the karst plateau. Today, farmers milk them there and the milk is brought back to the farm, in the polje. The ewes stay in pens at night, made with fixed or removable fences, where they have salt. They are moved to another night pen every 10 days, to ovoid overgrazing and erosion. A small area of those pens is dedicated to the milkings.

By the end of summer, the grass is too dry and the dolines (where ewes drink water) are empty. Thus, the ewes are taken down to the polje bottoms and benchlands, where they graze grass regrowth. The ewes stay outside until the end of December, even if there is snow

"Sheep can always eat outside... even when there is snow, they can dig holes and eat; cows cannot do that" (T-Liv-09).

The lambs drink their mother's milk and start eating grass when the herd is taken to graze in the polje in April. They are sold before the herd goes to the summer pastures on karst plateaus in May.

Table 8: C – Ration of the ewes (kg/day/ewe). Emmanuel Artus and Anouk Fraisse.

Winter ration: January – March	Hay (natural grasslands) Cereals (wheat, barley)	3 0,5 (January & February, lambing) 0,3 (March)
Summer ration: April – December	Pastures	At will *Karst plateau (May till August)* *Polje (April, September untill December)*

Working calendar

As in other dairy farms, milking and feeding the animals represent the basis of the work. They have one milking machine for the cows and milk the ewes by hand. Indeed, milking clusters are not adapted for the teats of the Pramenka breed. However, cheese-makers must also process the milk everyday (Figure 85). It is done with the milk from the morning and the evening before. It takes about 3 hours in summer and less in winter, as the ewes don't produce milk in winter. On the first day, cheeses are pressed and must be turned every 2 hours. Then, they are put in brine for 4 days. During the ripening period of the cheeses – around 1 or 2 months, they must be turned every second day. They are cleaned just before being sold.

From the 4th month to the 12th month, a shepherd is employed to look after the ewes. It represents a full-time job and can't be managed by family members only. The shepherd doesn't work on the farm for the 3 months of winter. However, the farmers go to the summer pastures in the evening, for milking the ewes. They spend the night over there, milk them again in the early morning and go

back to the farm for processing the cheeses. However, shepherds are hard to find, and water is lacking by the end of the summer. Less and less farmers are taking their ewes there. As the cheese is of better quality when ewes are taken to the karst plateau, farmers try to keep on preserving the use of summer pastures. Cows are already staying in electrical fences around the farm; it could soon be the same for the ewes.

As in the other family farms in the study area, the most labour-intensive period is the mowing season, from the 6th until the 8th month. Indeed, cheese-makers have the equipment for doing square haybales (around 20 kg), which require a lot of working hours. Family members come and help at the farm (relatives working in foreign countries and coming back for their summer holidays). Another, labour-intensive period of the year is the lambing period, in the 1st and 2nd months. It requires an increased surveillance of the ewes. This type of farm is highly time consuming and represents a lot of work. Farmers often mentioned how tiring it is. Indeed, almost all the months require 30 days of work (dark red line on Figure 85).

"We only have one hour of free time per day [...] there is no break during the day, we can't even celebrate Bairam, we work all the time" (H-Liv-014)

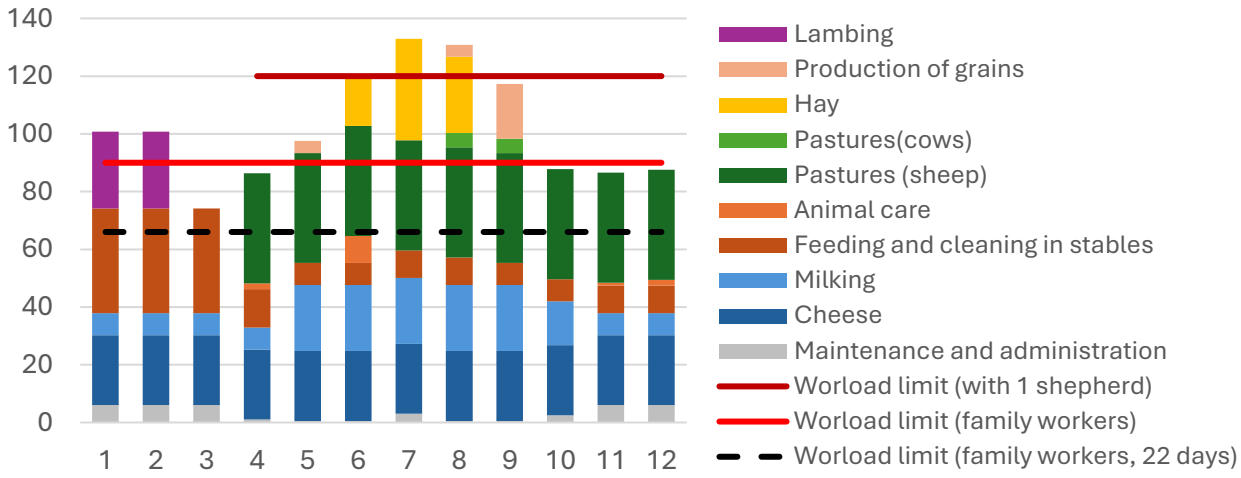


Figure 85: C – Working calendar, example with 300 ewes and 15 cows. Emmanuel Artus & Anouk Fraisse.

7. Traditional nomadic systems (N)

The description of this type of farm is based on the interview of 4 members of different families shepherding on the *Hrbina* (a karst plateau located between Kupres and Glamoč).

The nomadic production system is very similar to the cheese-making one. Farmers keep approximately the same number of cows and sheep. The cows stay around the farm, in Travnik (in the neighbouring Canton). The sheep pasture on a karst plateau in Canton 10 during summertime (the *Hrbina* for nomads, instead of the foothill of the Cincar for cheese producers). When water starts lacking on the karst plateau (by the end of August), they are taken to Kupreško or Glamočko poljes. The main difference between the two production systems is that in winter, the sheep also goes to pastures, in the northern plains of BiH (in Posavina). No shepherd is hired. Several families gather their herds and one member of each family goes to the pastures. It allows them to take turn in the shepherding, or for resting a few days or for going to the nearest village and bring back some food supply. Donkeys are used for carrying food and equipment – tents, sleeping bags, clothes, ... (on the left on Figure 86). Indeed, as they pasture on wide areas, they are moving with herd and sleeping in tents – they sometimes spent a few nights in temporary buildings, as old *katun* (on the right on Figure 86).

Another difference is that cheese is made with cow's milk only (and not ewe's milk). It is called Vlašićki cheese. The main production of these farmers is the sale of lambs around Travnik, mostly for the 1st of May, between summer and winter pasturing period.

Water availability limits the development of this system. Deep in the karst plateaus, huge grazable areas are available. Over those places, ponds used to be present in *dolines* (few meters wide depressions filled with sediments). They were maintained from one year to the other by the large number of animals grazing and thus compacting the soil (see Part III, 4.2). In this way, autumn and winter rainfalls were kept for the spring and summer pastures. *"There were hundreds of ponds here on Hrbina years before"* (H-Gla-05). With the depletion of animals, grass quality is also dropping, and encroachment gaining the upper hand…

Figure 86: On the left, a shepherd with donkeys and a herd of 1200 sheep, Hrustan Kadić. On the right, old katun serving as a shelter for nomadic shepherds, Anouk Fraisse

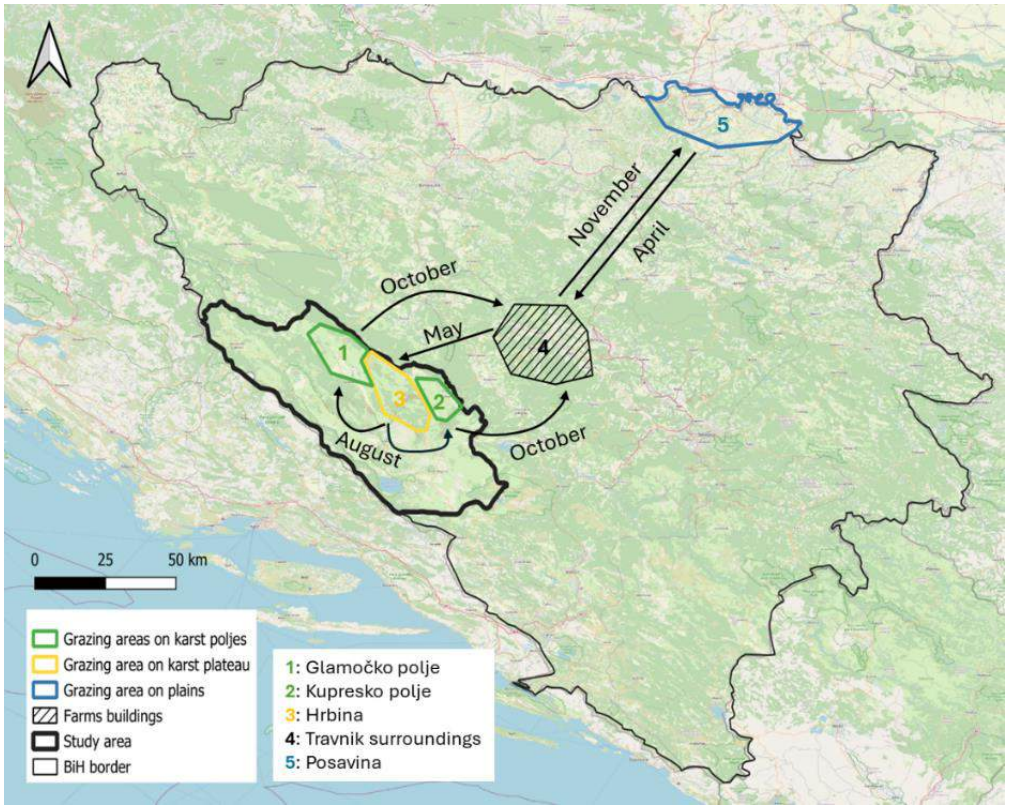


Figure 87: Current herd movements in nomadic shepherding systems. Emmanuel Artus & Anouk Fraisse.

8. Ewe-lamb systems (EL)

We realized this model thanks to 3 in-depth analysis, and 4 shorter interviews. All those farmers created their farm from scratches. They started the business as they *"saw sheep as easy money"* (H-Gra-05). Starting such a business requires rather low investments (small equipment for growing crops and mowing hay and one barn). As farmers couldn't contract loans on karst plateau public lands, they are not allowed to put fences on the plateau. Indeed, it seems not to be easy for everybody, especially when people are not from the majoritarian identity (Bosniak, Croat or Serb) of the municipality. Nevertheless, they can shepherd the animals on those lands, without paying any rentals.

On the benchland, farmers grow crops on their own plots, and mow hay on their neighbours" for free. On these plots, aftermaths are also grazed when shepherd bring sheep in the polje (between August and April). During that time, public lands from the polje bottom are also grazed. Even during wintertime and the presence of snow, whenever the weather is good, sheep are taken out for pasturing. This is the main difference with nomadic systems which take all the animals for winter season pasturing further away rather than keeping them in barns. Between April and August, sheep are shepherded on the karst plateau. For water issues on the karst plateaus, these farms only rely on the few natural streams and mainly on cisterns for bringing water to ewes. Even if sheep can bear staying a few days with only eating plants covered of dew, farmers bring them water during the driest summer months. Thus, they can stay longer on the karst plateau than nomadic systems which cannot do so, but they must be closer to the paths to bring the cisterns. Ewe-lamb systems are less deep in the karst plateau, on the sides of the polje (Figure 88).

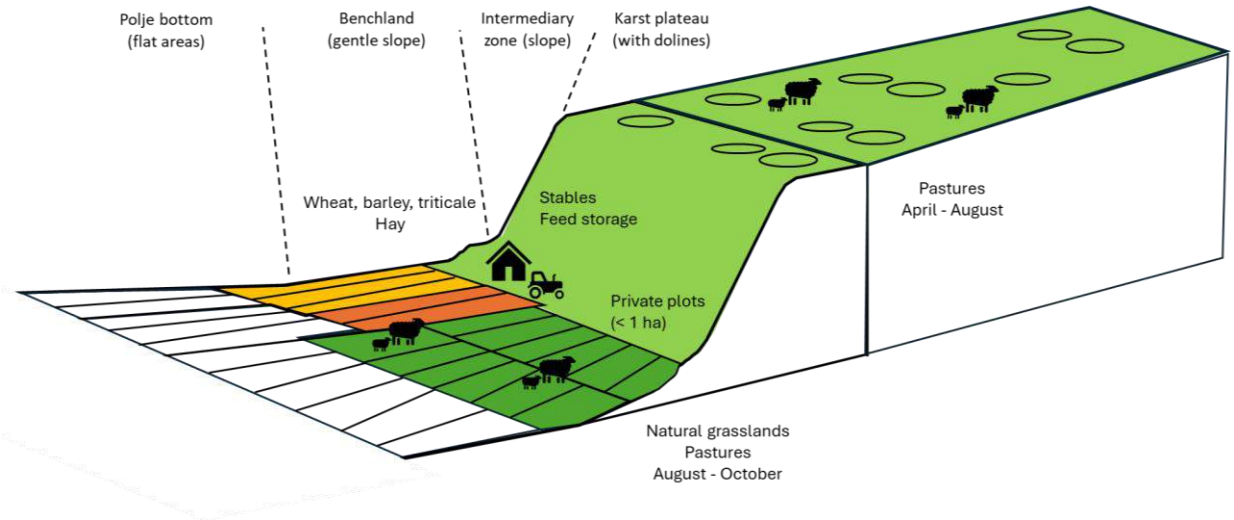


Figure 88: EL - used landscape units. Emmanuel Artus and Anouk Fraisse.

Global functioning

These systems are equipped for mowing hay and growing crops. The cropping equipment is not of the latest generation as there is only a few hectares of crops. As the nomadic systems, due to the high cost of a round baler, these farmers also produce square bales. They buy a small quantity of cereals every year. The rest of the feed is produced on the farm (Figure 89).

As all the production systems raising ewes, farmers don't sell lambs for fattening but for eating. Ewe-lamb systems are the only one killing the animals and selling them whole. Over the Canton 10, the demand is high in summer. It comes from the diaspora back home for the holydays,

weddings, and an increasing number of tourists. These meat production systems supply this demand with on-farm slaughtered animals. More than 60% of their production is sold during July and August. The celebration of the 1st of May is done with young lamb. Older lambs are sold for Christmas. Those two occasions represent another 20% of the global sells. Culled animals are sold alive for *Bairam,* mostly out of the Canton 10 (Figure 89).

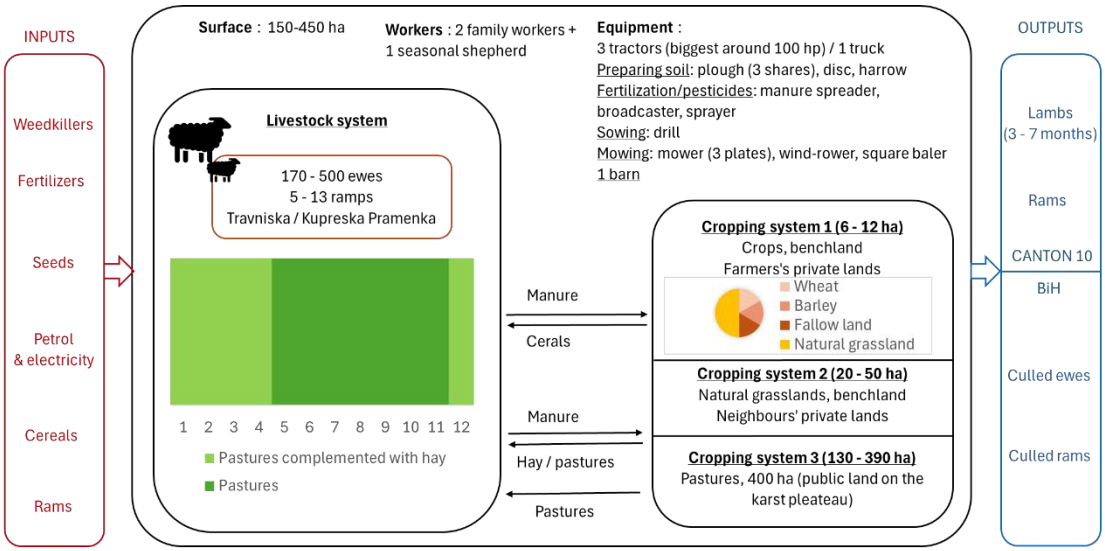


Figure 89: EL – Global functioning of the production system. Emmanuel Artus and Anouk Fraisse.

Cropping systems

The rotation of the first cropping system includes 4 years of fallow lands which turn naturally into grasslands *(1)*. They are mown except the year just after crops. It takes place on farmers' private plots, and a few plots rented from relatives who left abroad if needed. Compensation can be done with meat. As other familial farms, wheat and barley are grown as they fit with sheep feeding and climate conditions. As all the previous models, ploughing and tilling are done systematically before the crops. In addition to their manure, slightly more fertilizers than other familial models are used (about 300kg/ha). Weedkillers are applied once to twice a year, with a higher frequency than the other familial farms. Thus, these farmers have yields between the megafarms and the family farms (5 t/ha for wheat and triticale, 4 t/ha for barley).

(1) wheat / barley // fallow lands // grassland // grassland // grassland

The second cropping system is fertilized with the rest of manure. It is mown every year once, and aftermaths are pastures. Those are neighbours' private lands. The third cropping systems is on public lands. out of grazing, nothing more is done.

Livestock systems

The 450 ewes lamb in the beginning of Spring, so to have access to green pastures during, or shortly after, lambing. Naturally, lambing should be about January as in the cheese-making and the nomadic systems. Reproduction cycles are postponed by removing rams from the ewe's herd. The mortality rate is higher than nomads' and cheesemakers' herd which also (about 12%) because of wild animals in the pastures. Twins rarely survived without farmer care and remains the first cause of lamb death. Reproduction is ensured by rams raised in the farm. To maximize genetic diversity, a few ram lambs from the farm are exchanged with other farmers every year. The 100 ewe lambs kept for turnover have their first lamb about one year and two months old. Ewes are culled after 5 to 6 lambing (Figure 90).

Before going to pastures, farmers bath the sheep in a water-medicinal mix to fight external parasites. They give them pills for internal parasites before and after pasture season. Ewes often receive treatment against hooves injuries.

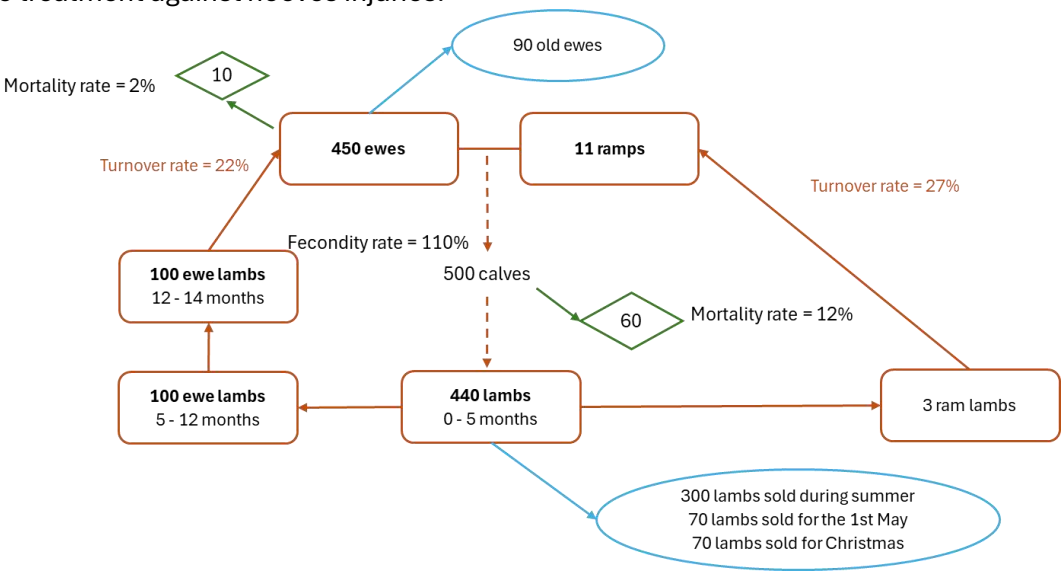


Figure 90: EL – Herd management, example for 450 ewes. Emmanuel Artus and Anouk Fraisse.

Feed management

Pastures are the basis of ewe-lamb production system. From May to October, sheep only graze pastures. A shepherd looks after them in the karst plateau until August, then in the polje until October. Later, the presence of snow doesn't compel farmers to bring ewes outside only when the weather is good. That's why until March, pastures are complemented with hay and grains in barns (Figure 89). Wheat and barley flour are given in flour. Sheep eat 300 grams per day and receive one extra 100 grams in April to help lambing (Table 99). Ewe lambs for turnover are fed the same way as other ewes.

Table 9: EL – Distributed feed (kg DM/ewe/day)

	January-March	April	May-November	December
Hay	2	2	0	1
Cereal flour	0.3	0.4	0	0
Pasture	At will	At will	At will	At will

With the difficulty of finding shepherd, the time for checking on them, and the cost of the wage, some farmers fence large areas and stop hiring shepherd. Ewes only need to be shepherded further away on karst plateau in the end of the summer, when they had consumed all the grass in their fenced area. Farmers managed it by themselves. It may be one of the coming trend for these systems on the next years, if farmers succeed in contracting loans.

Working schedule

The two familial workers are unable to manage alone the quantity of work during the mowing season. That is why a shepherd is hired in summertime. They provide him with accommodation and a good salary (2 500 KM/month), finding a shepherd being very difficult those days. In July, he stays even 30 days a month with the animals. Nevertheless, familial workers still go to the pastures to bring animals some water. It adds more work during the dense summer months.

During wintertime, shepherding, feeding sheep and maintaining the material are the two main activities for the two familial workers. A few times a month, if sheep came back wet, worker mulch the barn with homemade straw.

In the early spring, lambing is a non-stop activity which requires to be closed to the animal 24 hours a day. For the first lambing month, animals are in the barn. Nevertheless, they are quickly moved outside, increasing the quantity of work. This period is also the one of sowing barley. As they don't have time, only a few hectares of barley are manageable for farmers, who often need to purchase grains (Figure 91).

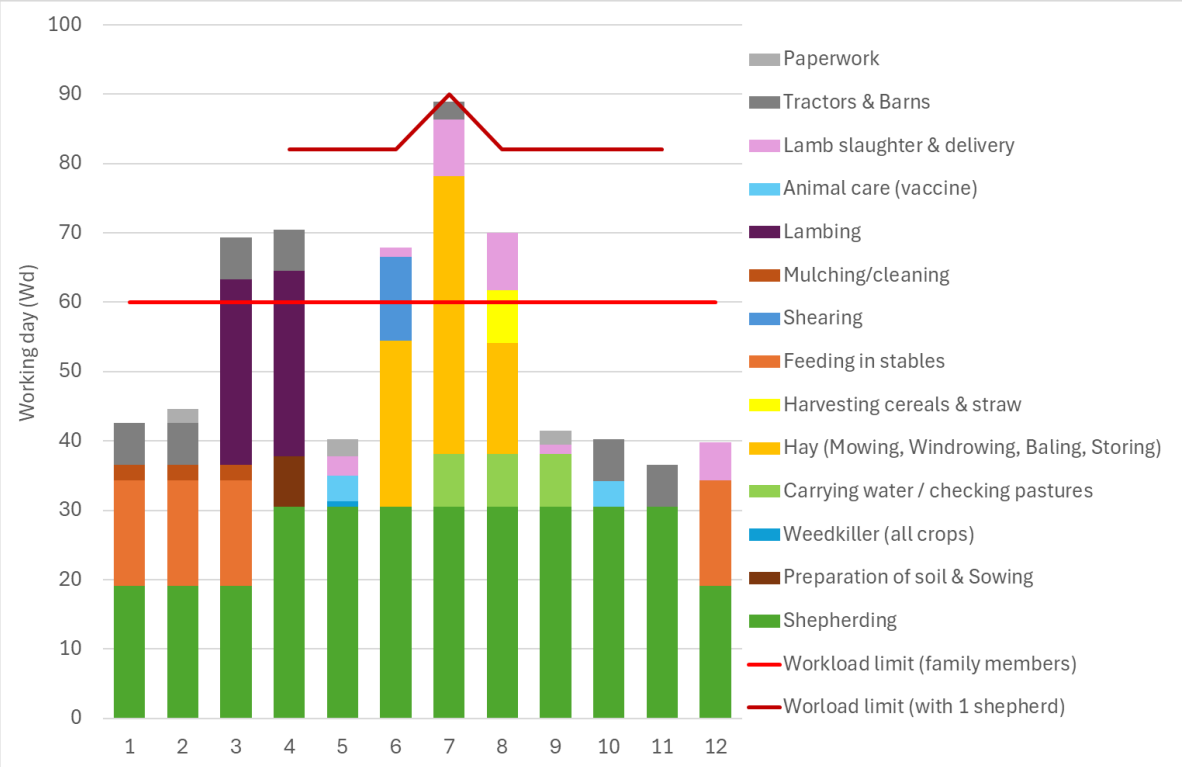


Figure 91:EL – Working calendar, example for 450 ewes. Emmanuel Artus and Anouk Fraisse.

9. Cow-veal systems (CV)

We built this model thanks to the in-depth analysis of 3 farms, and the interviews of 2 others. All those farmers created brand new production systems, without more than 5 ha of private lands, and without any traditional know-how on the study area. These farms require higher investments than ewe-lamb systems. The price for cattle is higher than sheep. Cows need a better access to water, which must be done with expensive drilling and anti-frozen troughs. Equipment is new and adapted to round bales (against small bales for ewe-lamb system). The contracts given by municipalities for the public land leases on karst plateau are a prerequisite for cow-veal systems. Contrary to the ewe-lamb systems, all of them succeed in obtaining contracts, allowing them to fence the pastures.

As ewe-lamb systems, these farms rely on wide areas on karst plateau for summer pastures, but also on larger areas on polje for winter pastures. Karst plateaus are empty enough for these farms to develop, but poljes remain too crowded for these systems which required dozens of unused hectares. For these reasons, they are far from the main cities, and then far from arable state lands – close to the main cities (Figure 37).

Down in the polje, farmers have about 10 ha for growing cereals, and a few dozen for producing hay. From August to October, cows graze these lands and some more in the polje in temporary enclosed areas. Farmer rent the private arable lands for crops, but none of the private lands for hay or grazing. On the karst plateau, these farms contract lands leases from the municipalities. This is their only way for setting electrical fences there (only grazing state lands without electrical fence can be done without contract). Thus, the animals pasture the karst plateaus from August to April thanks to opened stables in the enclosed areas. It can only be done thanks to water drillings filling antifreeze troughs (Figure 92).

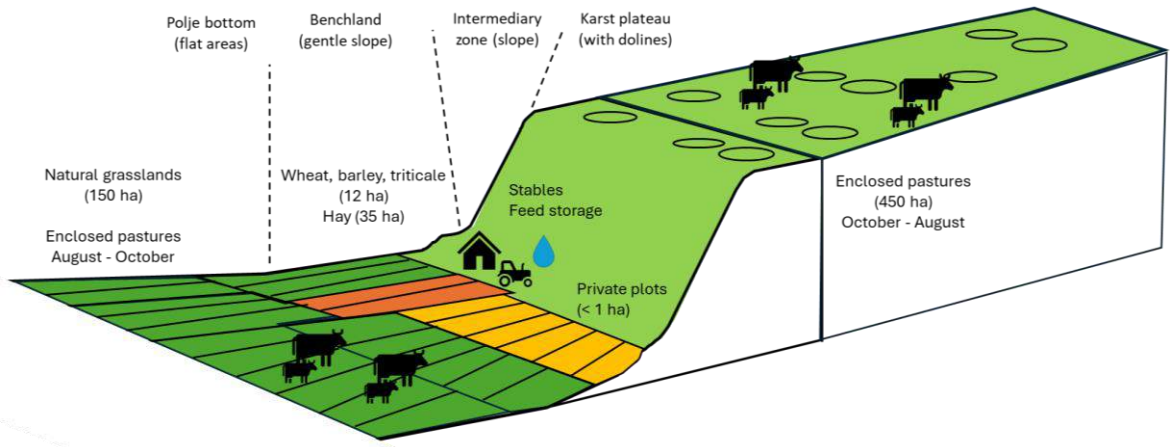


Figure 92: CV – used landscape units. Example for a farm of 650 ha. Emmanuel Artus and Anouk Fraisse.

Global functioning

Two family members work in the farm and oversee one employee. Salers, Limousine, Charolaise and Aubrac and are the main breeds. Contrary to ewe-lamb systems, these farmers sell animal alive and for further fattening out of the study area. Most of the required hay is bought from other farmers. Nevertheless, these farms produce about 30% of the hay thanks to recent mowing implements adapted for round bales (Figure 93). For growing crops, farmers have all the equipment except the combine-harvester for which they call contractors. The equipment is larger than the one of ewe-lamb systems. It is new, coming from EU funds for agricultural development in the countries willing to enter EU. Raising these funds also require political acquaintances.

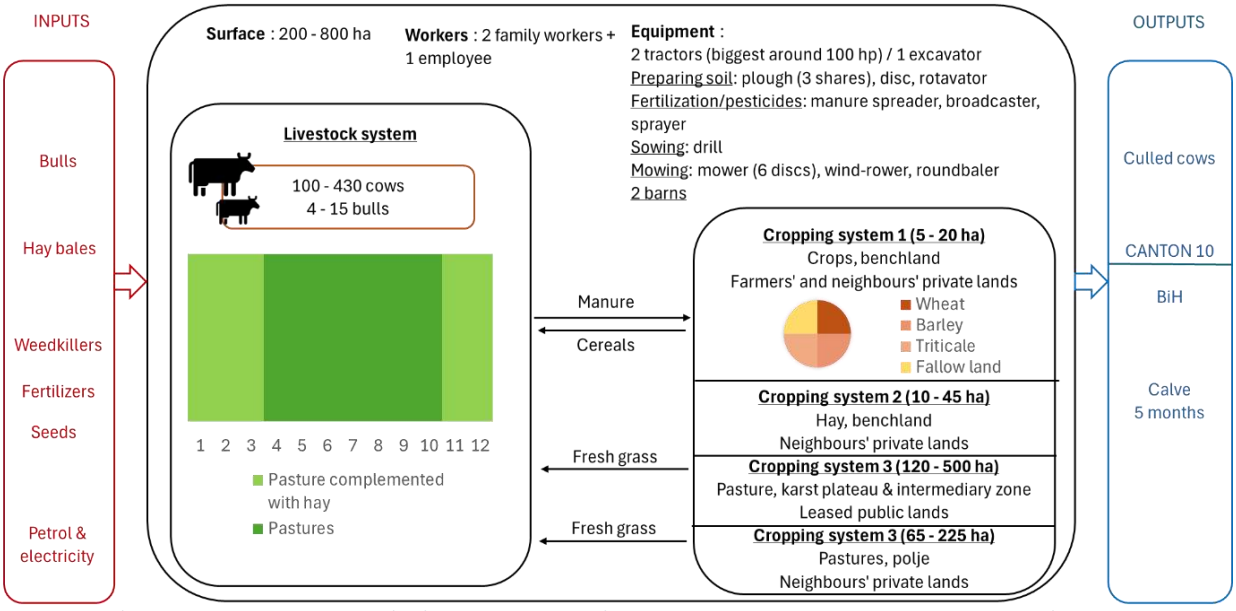


Figure 93: CV – Global functioning of the production system. Emmanuel Artus and Anouk Fraisse.

Cropping systems
This production system relies on one production system producing crops for complementing cows with grains during winter. The rotation includes one year of fallow land (Figure 93). Fertilization, soil preparation and weedkillers practices are the same as ewe-lamb farms. Thus, these farmers also have high yields (5 t/ha for wheat and triticale, 4 t/ha for barley).

The second cropping system take place on neighbours' private lands which are mown. As other models in this case, only the remaining manure is applied on these plots.

Livestock system
Farmers raise 1 bull for 30 cows. Meeting is done in autumn so as to have calving in the pastures. Thanks to rustic breeds, the fecundity rate is high, about 95%. Nevertheless, the mortality rate is the second highest in the study area (about 5%) because of wolves' attacks (Figure 94). The 10% turnover rate is lowest than in production systems for milk production.

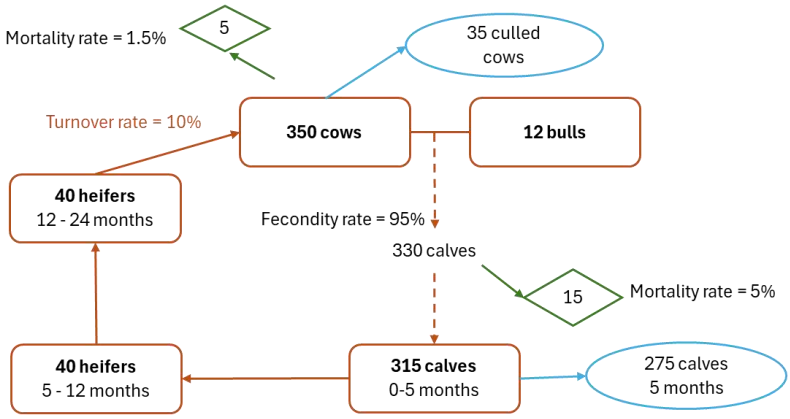


Figure 94: CV – Herd management. Example for 350 cows. Emmanuel Artus and Anouk Fraisse.

Animal feeding
Starting from November, when the vegetation growth is limiting, cows are complemented with hay on the karst plateau. From December to February, their feed is mostly composed of hay and cereals although they can graze freely on the plateaus (Figure 93). Calves head their mother until they are sold. Heifers kept for turnover have the same feeding as the cows. Distributed feed is described in Table 101010.

Table 1010: CV - quantities of distributed feed. Emmanuel Artus and Anouk Fraisse.

Winter ration	Pastures At will Hay [7; 12] Cereals (wheat, barley, triticale) [1; 2]
From April to October	Pastures At will

Working calendar
This type is characterized with comfortable working calendar out of the working peak for collecting hay. It would require more people to mow all the hay consumed in wintertime. That's why 75% of the hay is bought in the study area. Most of the work is about transporting and storing the bales. The 25% left are mowed by the farmers and the employee. This is the only production system not producing all its fodder. Thanks to fenced area directly connected to the barn and the automatic filling of water troughs, there is no need for checking animals every day. It only requires

a few hours three to four times a week to check animals, fences, minerals and water. In wintertime, complementing animals and maintaining barns are the most burdensome tasks (Figure 95).

On the grazed karst plateaus and hilly complexes, years of abandon left the lands full of unwilling grasses (thistle, bramble). On the first year of installation, they should be shredded to limit their expansion. This task is less needed as grazing increases. When these production systems reached their definitive number of animals and lands, shredding become useless. One should keep in mind that this time-consuming task is not included in Figure 95 but represent a consequent quantity of work during May and June.

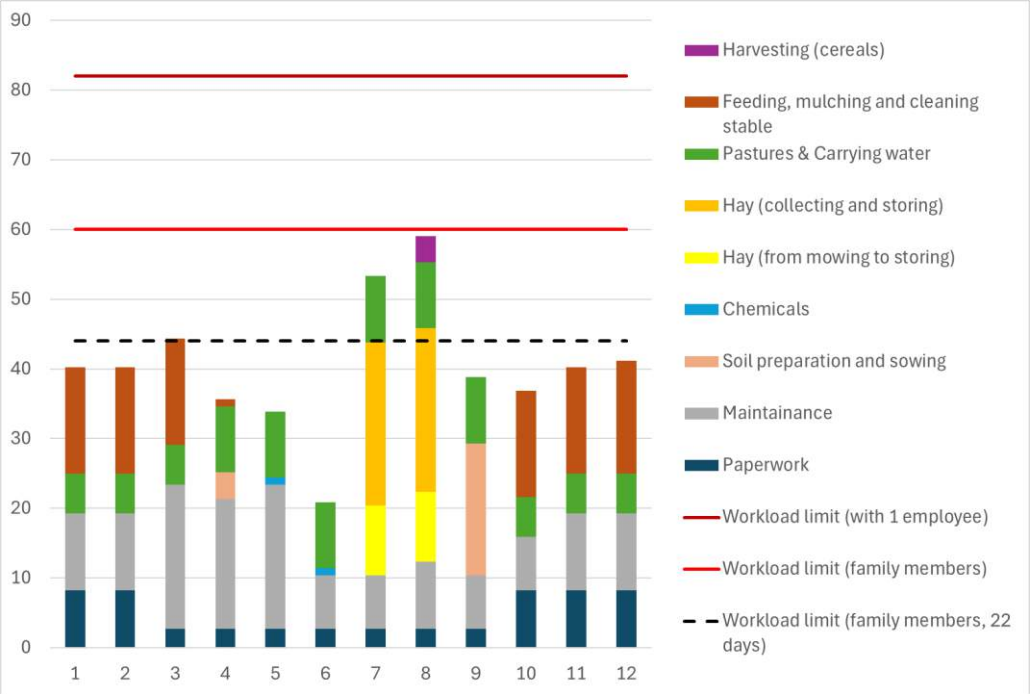


Figure 95: CV - working calendar, example for 350 cows. Emmanuel Artus and Anouk Fraisse.

10. Megafarm on cow-veal system (CV-XL)

This description was done thanks to the interview of one employee and the observation of the farms as the managers never agreed on an appointment.

In the municipality of Kupres, the former State farms buildings have been bought after the war by one investing family. Alongside with other activities such as petrol station, cow-veal systems with black and white Angus were developed. Kupres State farm was split into different location, and the investor started three independent farms on three of these location. As they grew, the family developed new farms on the same model reaching at least 6 structures. They are each managed by employees and the capital of the farms belong to the investor.

As in the cow-veal systems (IV, 9.), they rely on large areas for grazing on karst plateau – about 1 ha per mother cow. They have contracts for it and the summer pastures are also fenced with the stable inside. Once again, the cows graze aftermaths in the polje after September. The main difference with cow-veal systems is that animals are kept in stable during wintertime and fed with corn silage, cereals silage and hay produced on the farm. For it, the megafarm on cow-veal system rent public arable lands in the benchland and the polje bottom. They manage about 1 hectare per

cow, again 0.1 for cow-veal systems. As them, they are equipped with new and powerful equipment, but also possess all the implements for making corn silage (Figure 50).

To face the same scarcity of water as cow-veal and ewe-lamb systems, this model relies on drilling and also on direct pumping in the rivers around. The difference with cow-veal systems is that there is no usage of troughs. Water is simply poor in dolines, without any prevention on leakages (Figure 97).

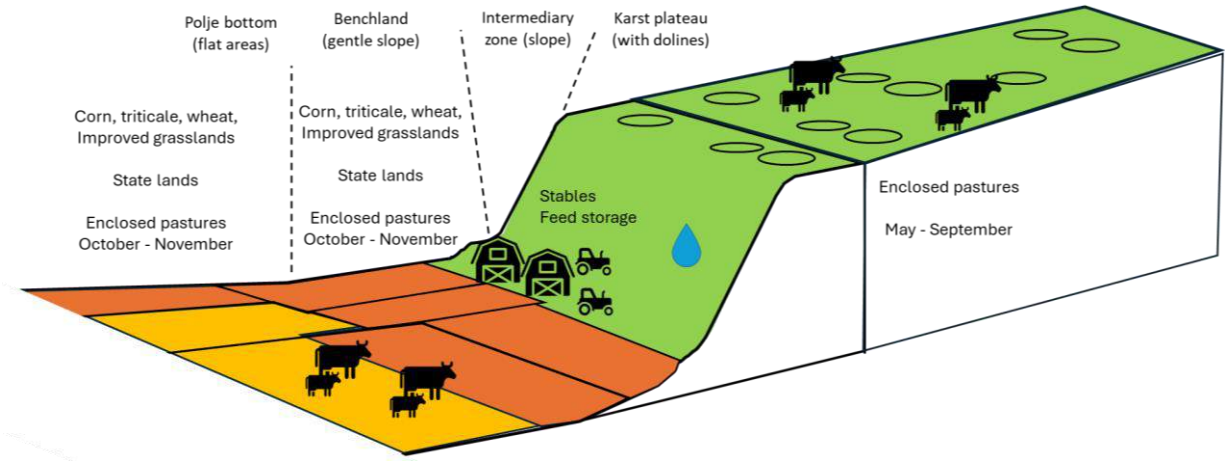


Figure 96: CV-XL - Landscape units used. Emmanuel Artus and Anouk Fraisse.

Figure 97: Right: doline filled with water. Left: pipe running from the stream to fill the doline.

Part V: Economic analysis of the production systems in the study area

1. Gross product (GP) and net added value (NAV)

To evaluate the economic performances of the different types of farms of the study area, we first estimated their gross product. It corresponds to the money generated by the sales of farmers: lambs' meat for farmers raising sheep, milk for those having dairy cows, for example. To be able to compare the different types of farms, we calculated the GP per animal in number of ACU[12]). We did this calculation for the 6 models we built (Figure 98).

Megafarms producing cows' milk have the highest GP per ACU. Indeed, the milk production per cow is the highest in this type of farm. On the opposite, as side-farmers have the lowest milk production per cow, their sales generate the least money of all milk production systems. Medium family farms for milk production are in the middle: the milk production of their cows is higher thanks to silage and haylage but still doesn't reach the one of megafarms. Indeed, animals are taken to pastures. Their feeding is more dependent on the season than on their stage of lactation – in opposition with the cows in megafarms, always kept in stable.

Farmers raising sheep for meat production, slaughter the lambs and the meat is cut and packaged on the farm. In the cow-veal system, calves are sold alive for further fattening. It leads to a better selling price per kg of meat for lamb's meat (around 15 KM/kg or 7,50 €/kg) than for calves (around 8KM/kg or 4 €/kg). Thus, farmers raising sheep receive more money per animal from their sales than those raising cows (their GP is higher).

As cheese makers rely both on the sales of lambs and cheeses, their sales generate more money than for farmers only selling lambs' meat. Their lambs are sold younger and cheaper, but the cheeses they can produce after selling them exceed this price difference. However, the generated money per animal is similar to medium family farms. In fact, each cow produces about 1 000 litters more – representing about 850 KM/ACU. This difference is compensated with the low valorisation of the milk in cheeses – about 890 KM/ACU.

[12] The ACU (Adult Cattle Unit) is a coefficient which facilitates the aggregation of livestock from various species and ages. The reference unit used for the calculation of livestock units (=1 ACU) is the grazing equivalent of one adult dairy cow producing 3 000 L of milk annually. We used 0,14 for sheep. Only the mothers are taken into account in our calculations (no calves nor lambs or heifers, rams, etc…).

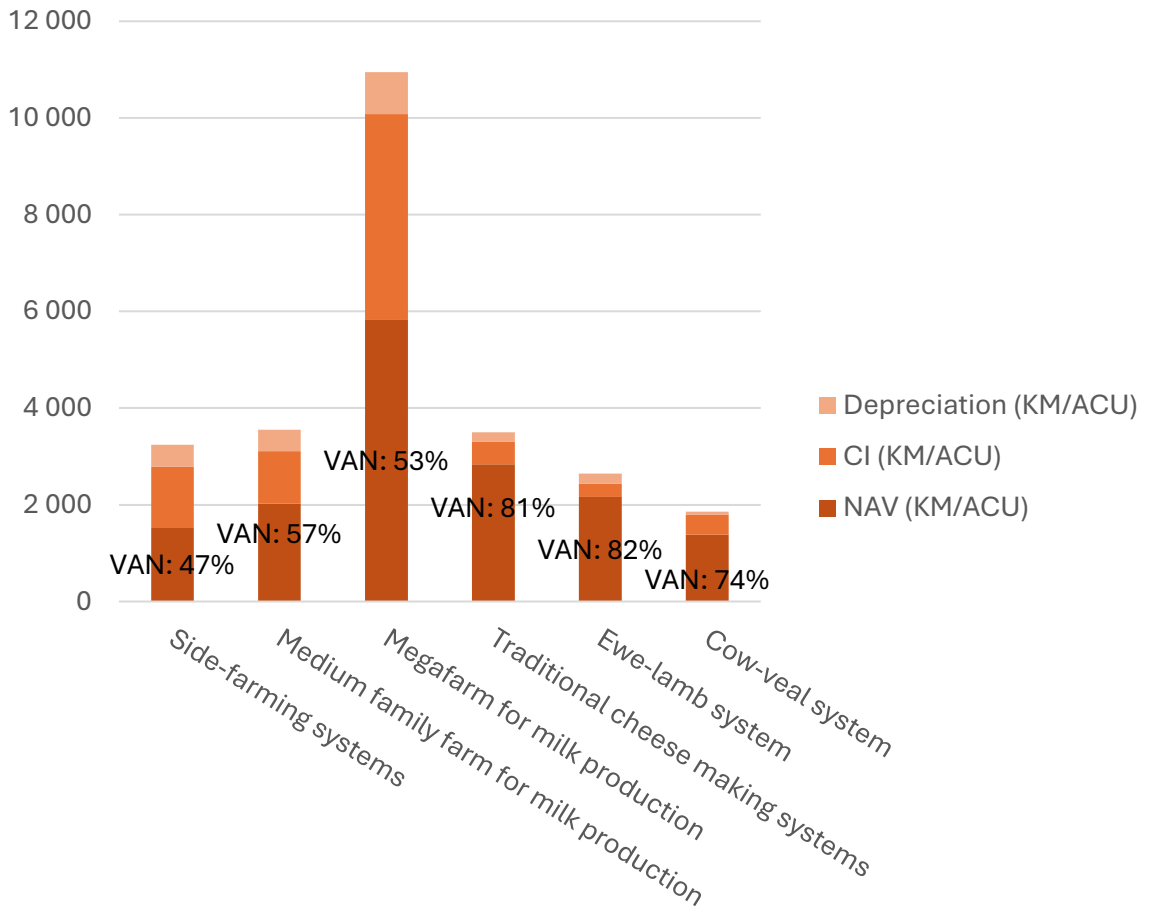


Figure 98: From GP to NAV, in KM/ACU. 2 KM = 1€. Emmanuel Artus and Anouk Fraisse.

To calculate the wealth created (or net added value – NAV) by each type of farm, we removed the depreciations (the cost of equipment and buildings per year) and the intermediate consumptions (cost for seeds, fertilizers, fuel, ... per year) from the GP (dark orange on Figure 98). As farmers have smaller or bigger expenses depending on their systems, what is "left" from the GP varies from one type of farm to the other (indicated in % on Figure 98).

For all milk production farms (Figure 98), the VAN represents around 50% of the GP. Thus, the observations on the quantities of milk produced made for the GP/ACU explain the differences for the GAV/ACU of all milk production farms.

For cheese makers (Figure 98), the VAN represents around 77% of the GP. Indeed, they use less fertilizers and weedkiller per ha than milk production farms. The depreciation is very low because farmers have old equipment, often bought second-hand. Moreover, there is no milking machine for the ewes – milkings are done by hand. Only milking buckets are used for the cows (there is no milking stalls, as in medium farms, for example). Thus, cheese makers create more wealth per animal than medium farms.

For farmers raising sheep (Figure 98), nothing is needed for processing milk (no starter culture nor cheese-making room, for example). Moreover, as the animal needs are lower and their feeding relies on summer pastures, less crops are grown (meaning less seeds, and fertilization) than for cheese makers. Their VAN represents 82% of the GP. The total amount of depreciation is higher on cow-veal systems, as they also have water drillings, troughs and bigger barns. Nevertheless, as they don't produce all their feed, they need less mowing and cropping equipment per ACU, and

thus, have fewer depreciations. On the contrary, their intermediate consumptions represent more money than in farms for lambs' meat. Veterinary services also represent more money per animal. All this considered, the VAN per ACU represents 70% of the GP (Figure 98). Again, the observations on the price of the meat made for the GP/ACU explain the differences for the GAV/ACU of meat production farms.

In addition to the NAV/ACU, we compared the NAV/ha (wealth created per surface unit) and the NAW/Wd (wealth created per working day) for the 6 models we built.

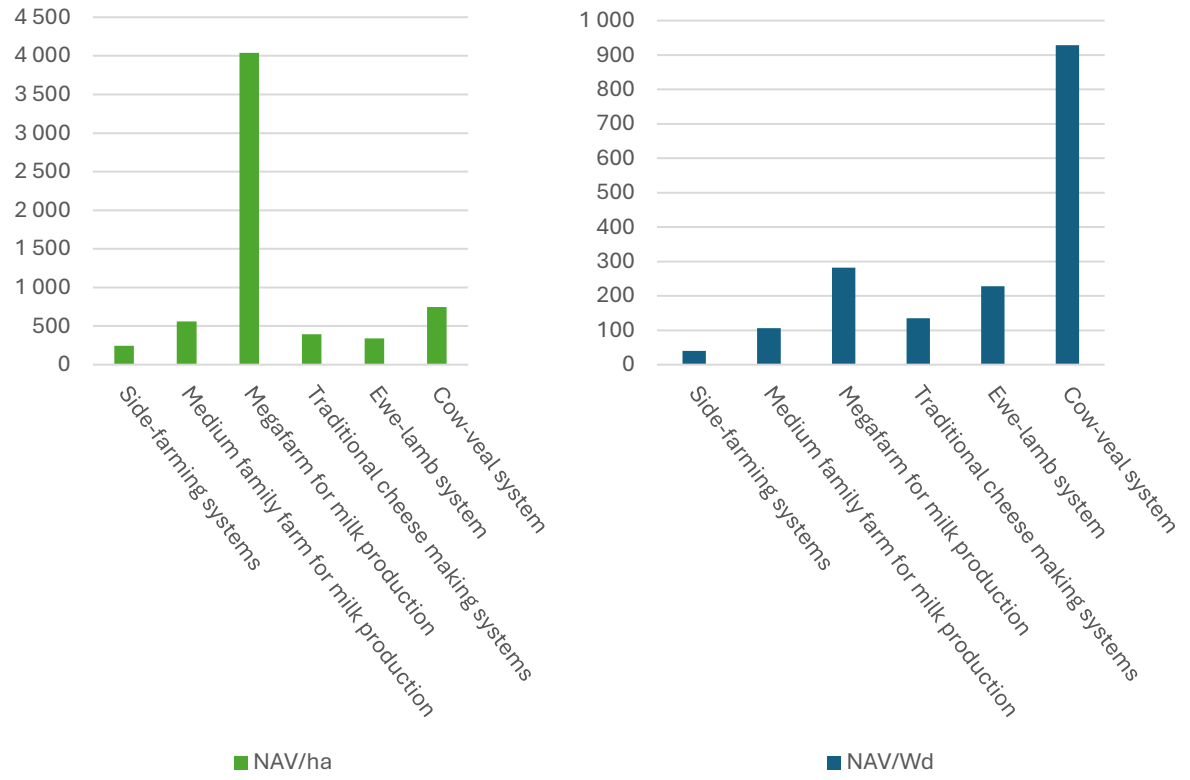


Figure 99: On the left, GAV in KM/ha. On the right, GAV in KM/Wd. 2 KM = 1€. Emmanuel Artus and Anouk Fraisse.

When comparing the NAV/ha, megafarms for milk production (Figure 99, graph on the left) clearly stands out. It generates over 10 times more money than any other type of farm. All lands are used for growing crops aiming at a better milk production per cow. Moreover, these crops are very productive: 1 ha of corn allows to feed more animals than 1 ha of pastures, for example. Indeed, the farms using both pastures and growing crops for haylage or silage generate less money. For side-farmers, less money is created per ha. It can be explained by a lower milk production per cow, linked to their feeding (they don't have any silage or haylage). As they use vast areas of pastures on the karst plateaus, cheese makers are one of the least productive systems per ha. In the ewe-lamb production system, farmers use about the same surfaces for summer pastures. Both deliver a "finished product" that they sell directly to consumers. However, cheeses are not well valued compared to lambs' meat, so the NAV/ha is slightly lower for cheese makers. In the cow-veal production system, farmers generate more wealth than for farmers raising sheep. In cow-veal systems, there is around 0,6 ACU/ha while there is about 0,15 ACU/ha for ewe-lamb systems. Indeed, the cows are kept on fences pastures whereas the sheep have access to more lands thanks to the shepherding. Thus, 1 ha generates more wealth for people raising calves.

As for the performances based on the number of working days (on the right, on Figure 99), the cow-veal system clearly stands out. Farmers generate around 5 times more money per working day than farmers of the other types of farms. Indeed, it doesn't require a lot of work, as the

pastures are managed with electric fences. On the opposite, the megafarm for milk production (M-XL) require a daily presence for feeding the cows in stable. Moreover, milking is done three times per day. Still, of all milk production farms, it is the one with the best NAV per working day. Indeed, in medium family farms, the production of hay is quite time-consuming, and the cows produce less milk. As the GP of cheese makers is 50% lambs' meat and 50% cheeses, their NAV/Wd is better than the one of side-farmers and slightly better to the one of medium family farms. However, raising sheep only for the lambs' meat don't require to milk the animals and process cheeses every day. Thus, the ewe-lamb production system generates more money per working day. As the shepherding asks for a lot of work, farmers raising lambs have a lower NAV/Wd than farmers raising calves.

2. Agricultural income (AI) and subsidies

The NAV is divided between land leases, employees' wages and interests on borrowed capital, and subsidies are added to arrive at the agricultural income (AI). As there are no taxes on land in FBiH, they are not taken into account in this calculation. Of the interviewees, none was keen on sharing information on the interests; it is not taken into account in this calculation either.

To show the importance of subsidies in farmers' income (and how dependant on them some farms are), we first calculated the AI without them. As for the GP, we did the calculation per ACU, to be able to compare the different types of farms. It was done for our 6 models. (Figure 100).

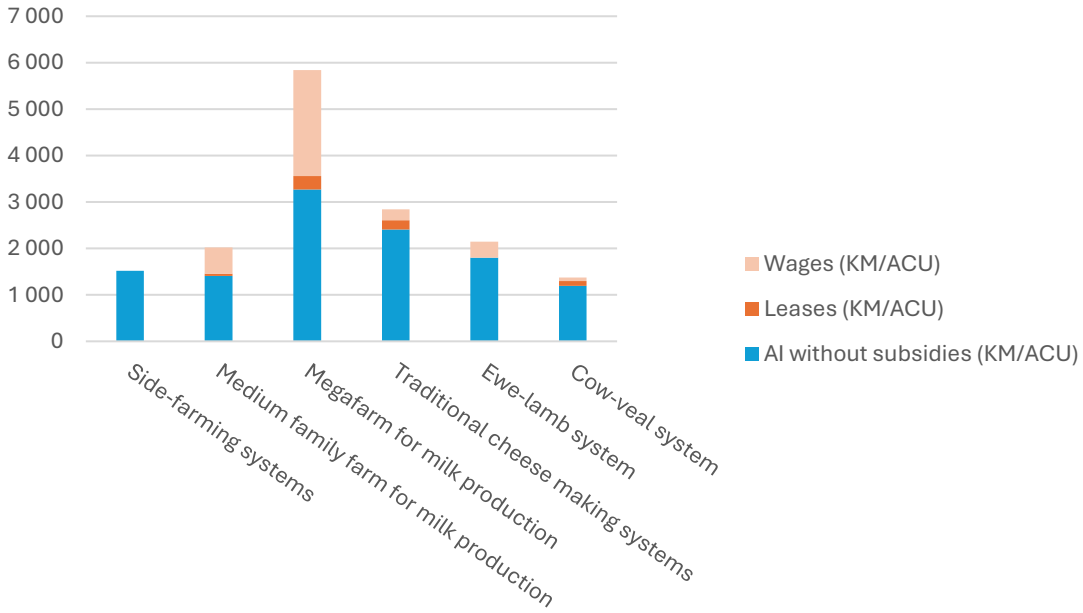


Figure 100: From NAV to AI, in KM/ACU. 2KM = 1€. Emmanuel Artus and Anouk Fraisse.

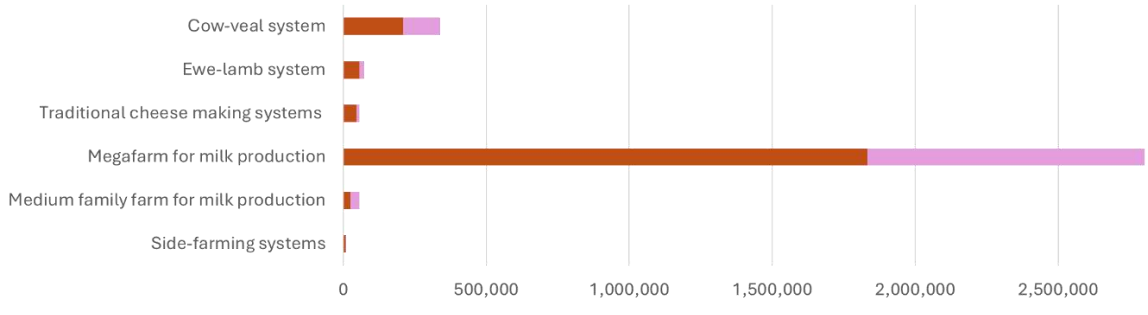
Some farms of the study area lease land: medium family farms, cow-veal systems and megafarms for milk production. Indeed, the megafarms (Figure 100) don't own any private plots (apart from the ones on which the farms buildings are located, less than 1% of the total surfaces). Leasing public arable lands costs 200 KM/ha/year. Moreover, it only relies on employees – 44 of them paid 2 200 KM/month – for carrying all the work (the owner doesn't work on the farm). Thus, 56% of the NAV goes to the owner of megafarms. In cow-veal systems (Figure 100), farmers lease public lands for pastures (to be able to put fences) for 80 KM/ha/year. They also lease some private plots for crop production, around 150 KM/ha/year. As family members also work on the farm, only one permanent employee is hired. Around 87% of the NAV go to the family members.

In medium family farms (Figure 100), one employee is hired to carry out the extra work that cannot be done by the 2 family members, paid around 1500 KM/month. These farms also rely on their neighbours' private plots for crop production, leased for 150 KM/ ha/year. However, the public lands they use for summer grazing is free. All in all, it represents a smaller cost than for megafarms and cow-veal systems. Indeed, around 70% of the NAV is left to the family members.

The cost of land lease for cheese makers (Figure 100) is very low in comparison with other farmers (they only need a few hectares). In ewe-lamb systems, farmers own all the land required to produce feed for their animals. In these types of farms, one shepherd is employed and is paid around 2 200 KM/month. For both of them, between 80% and 90% of the NAV is left for the family workers. It means that, without taking into account the subsidies, these two types of farms have the best pay. As side-farmers don't lease land nor hire employees, 100% of the NAV is left for them.

To this amount of money left, subsidies are added. Farmers can register as legal or physical person for obtaining subsidies. In FBiH, subsidies are allocated by the entity (Annex 8), by the cantons (Annex 9), and by the municipalities (Annex 10). The entity gives higher subsidies to legal than physical person (Annex 8). In RS, subsidies are only allocated by the entity. Entities and cantons have been running subsidies for 2 decades, while municipalities only started the process a few years ago. On the study area, the municipalities of Kupres, Livno and Tomislavgrad are the only ones giving subsidies.

In the study area, farmers mainly rely on the subsidy (from FBiH) given for the quantity of milk they produce. It is of 0,42 KM/L for legal persons and 0,40 KM/L for physical persons. It is based on the litters of milk sold to the dairies (local or not). When subsidies are taken into account, the differences of agricultural income (AI) in the different types of farms completely changes (Figure 101).



	Side-farming systems	Medium family farm for milk production	Megafarm for milk production	Traditional cheese making systems	Ewe-lamb system	Cow-veal system
% subsidies in AI	25	56	59	17	23	38

Figure 101: Total agricultural income and proportion of the subsidies, in KM/person/year. 2 KM = 1€. Emmanuel Artus and Anouk Fraisse.

Indeed, this time, megafarms (Figure 101) for milk production clearly stand out. Their AI is over 40 times higher than in any other system. Indeed, the milk production per cow is pushed at its maximum; and subsidies represent around 60% of the AI. It means that a farm with 560 dairy cows (producing about 9 000 L/cow) would receive about 2,6 million KM/year (or 1,3 million €/year) from FBiH. Of all the milk production types, only side farmers (Figure 101) have a low proportion of subsidies in their AI – around 25%. It is due to a low amount of milk produced per cow. Moreover, as side-farmers are registered as physical person (instead of legal person for the other types of farms), they amount of subsidy per litter of milk is lower. For a farmer raising 5 cows (producing about 2 500 L/cow), 850 KM/year would be allocated from FBiH. However, as they receive less

subsidies than farms registered as legal person and to compensate this difference, Canton 10 also gives them subsidies: 150KM per milked cow.

To a lesser extent, cow-veal systems (Figure 101) also stand out; the proportion of subsidies in their AI is around 40%. The development of this type of farms is encouraged by FBiH. It allocates specific subsidies to cow-veal systems (Annex 8), in addition to the subsidies for breeding heifers available for any production system.

On the other hand, ewe-lamb systems (Figure 101) and cheese-makers (Figure 101) don't benefit from these subsidies; they mainly depend on the sales of their products. Indeed, FBiH gives lambs' meat producer only one subsidy for breeding sheep (Annex 8). As cheese makers sell lambs' meat, they also receive this subsidy but none for the production of milk or cheese. Thus, Canton 10 decided to allocate 1700 KM/year/farm for processing cheeses – after some farmers complained about the situation. However, it is only the case for cheese makers producing Livanjski sir under the PDO label – all other cheesemakers don't benefit from it. Their economic situation is still difficult, and farmers have three options:

- to stop processing cheeses and to sell their milk to dairies during wintertime (for receiving subsidies for milk production),
- to completely stop cheese making (as it represents too much work in comparison to the work it requires),
- or to dissociate the dairy from the farm so to sell their milk to their own dairy, enabling the farm to be subsidized for milk production (one farm of the study area chose this option, but it requires a lot of administrative work).

However, cheese makers are the most likely to keep on operating when BiH will enter EU. Indeed, subsidies depending on the amount of milk are not allowed in EU. All the systems based on milk production would end up losing up to 60% of their income. Moreover, it would be easier for cheese makers to sell cheeses made with raw milk in Dalmatia. It would enable them to have the added value required by the processing of the milk. People producing lambs' meat and calves for fattening would be less impacted by BiH entering the EU, as a part of the subsidies attributed is based on the surface.

After calculating the AI/person, we linked it to the surface (and thus the number of animals) farmers can manage. It enables to show all the potential farms composing one type of farm, represented by segments (Figure 102). The gradient of each segment represents the amount of money added when farmers (or owners) increase the size (in ha) of their farms. Again, this calculation was done for our 6 models.

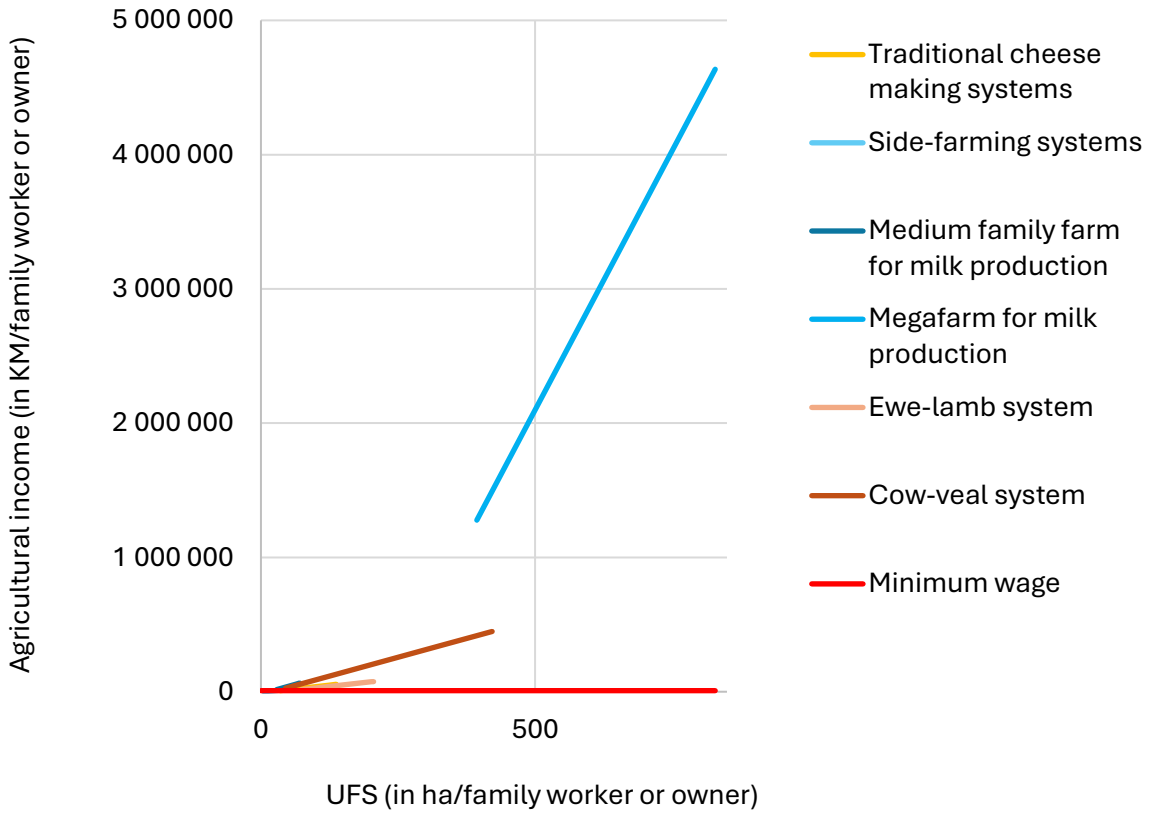


Figure 102: Agricultural income per type of farm, in KM/ha/family worker or owner. 2KM = 1€. Emmanuel Artus and Anouk Fraisse.

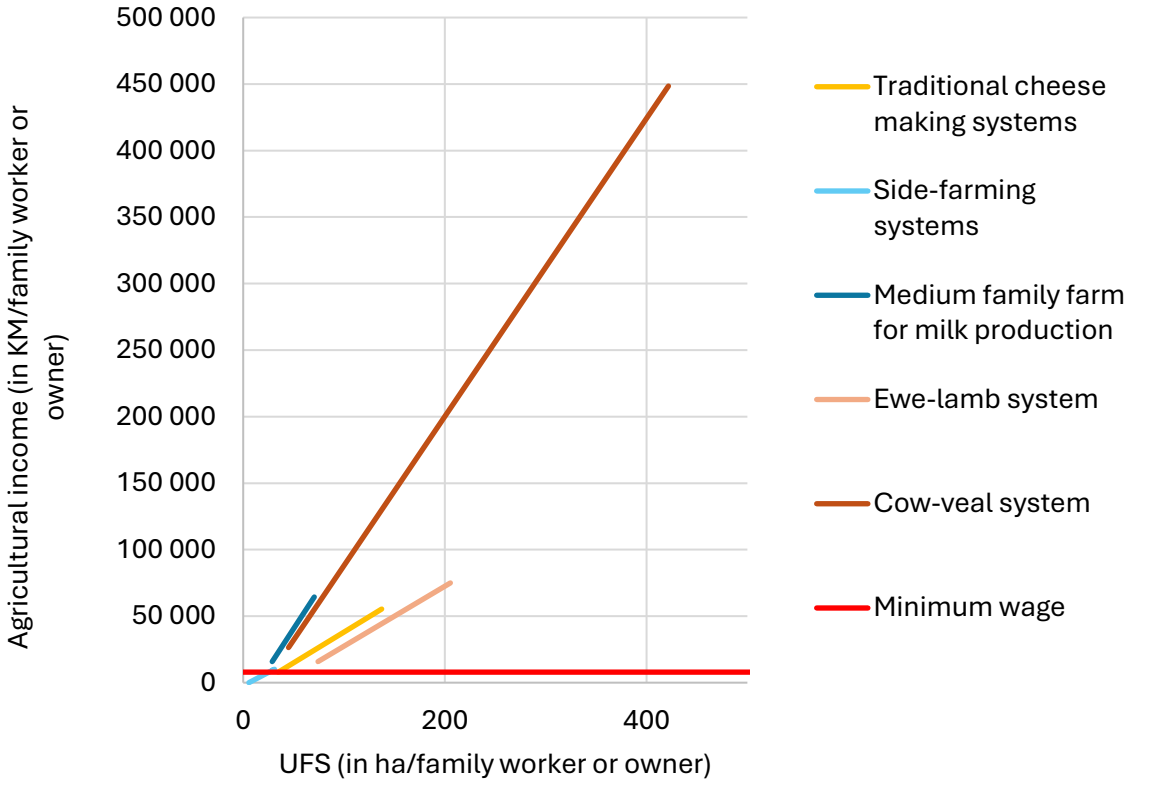


Figure 103: Agricultural income per type of farm, in KM/ha/family worker, without megafarms for milk production. 2KM = 1€. Emmanuel Artus & Anouk Fraisse.

The megafarms for milk production stands out from all types of farms (Figure 102). It is economically interesting for investors over 400 ha. This production system is made possible by the use of large plots of public arable lands. As most of those lands are already managed by the three megafarms, people cannot start farms based on this model. It illustrates the difference with large-scale farms for milk production, built on private plots, which don't exceed 300 ha. These large plots enable a big production of silage (corn and cereals), given to the cows all year round. This type of feeding gives a milk production of about 9 000 L/cow. As the subsidies are given per litter of milk produced, each ha added to the UFS (useful farm space) increases the AI by 5 500 KM (represented by the gradient of the line on Figure 102). The maximal surface that can be managed is about 850 ha. The agricultural income is divided between all the potential owners; however, as we don't know how many they are, we counted one owner in our calculation. All the other types of farms only use private plots for crop and hay production, their maximum surface is much smaller than the one of megafarms. To ease the comparison, we draw a second graph without megafarms (Figure 103).

Side-farmers (Figure 103) are the only ones to have farms which don't enable to earn the minimal wage: 600 KM/month (300€/month, red line on Figure 103). Indeed, as it is a side activity (in addition to a pension or another job), they don't need to earn enough to make a living out of it. One farmer is alone on the farm most of the year and family members always give a hand for mowing hay. Thus, the surface that can be managed is quite small: from 5 ha to 35 ha.

In medium family farms (Figure 103), agriculture is the only source of income. As the minimal wage in BiH is very low (and doesn't allow comfortable living standards), farmers manage a minimal surface of 30 ha/family worker, to generate at least 1500 KM/month. Again, their subsidies are based on milk production and the cows produce more milk than in side-farms (3 000 L/cow for medium farms against 2 500 L/cow for side-farms). It means that for 1ha more, farmers increase their AI by 1000 KM (500€), which is more than side-farmers. The maximal surface that can be managed by 1 family worker is about 70 ha.

On the opposite, cheese makers and people raising sheep for lambs' meat rely on a very low subsidy per sheep. Only *Livanjski sir* cheese producers receive an extra 1 700 KM/farm/year. Each time they add 1 ha to their USF, the increase of the AI of these two types of farmers is quite the same.

In traditional cheese-making systems (Figure 103), farmers don't receive subsidies for milk production. The subsidy for producing *Livanjski sir* is the same for all the producers of *Livanjski sir*; it does not depend on the quantity of cheese produced. For an average cheese making system (15 cows and 350 sheep), it represents 0.01 KM per litter of milk produced against 0.4 KM/L of milk for other milk production systems. It means that when cheese makers increase their UFS, they increase their AI by a lower amount of money than farmers producing milk – about 500 KM (250€), 50% less than in medium farms. In other words, for the same surface, the AI of cheese makers is lower than the one of farmers having medium farms and producing cow's milk. In this type of farms, one family worker can manage between 65 ha and 140 ha. The minimal surface enables the family workers to earn at least the minimal wage.

Alike cheese makers, people who developed ewe-lamb systems (Figure 103) produce lambs' meat. However, people raising sheep only for meat don't have to milk the animals and process cheeses every day. It allows them to take care of more animals and to be able to manage a higher number of lands (their UFS is about 80 ha more per familial worker). Thus, the money not made through cheese sales is compensated by a bigger number of animals. For each ha added to the UFS, farmers increase their AI by the same amount of money as cheese makers. This type of farm relies on a shepherd to take the sheep to the summer pastures. However, they are more and more

hard to find (due to better seasonal job opportunities elsewhere, especially is Dalmatia). Thus, some farmers raising sheep started to use electric fences on the pastures. However, their access to public land is limited and slows down their development (lands are leased to the ones who were using them first or to the ones giving the biggest amount of money).

As explained before, the money generated by 1 kg of meat is twice smaller for people raising calves than for people raising lambs. However, they have more subsidies per animal (740 KM/ACU against 530 KM/ACU) and more animals per hectare. Those things compensate each other and the gradient in cow-veal systems (Figure 103) is similar to the one for cheese making systems and ewe-lamb systems. Moreover, as the cows stay in fenced pastures, the herd management is less time consuming. Farmers can thus manage up to twice more surfaces than in ewe-lamb systems: it goes up to 420 ha/family worker. It also means that the AI can be higher for people in the cow-veal systems than for people in the ewe-lab system. However, cow-veal systems assumes that farmers have access to fenced pastures on public lands, which is more likely to happen for those having well developed networks of acquaintances. Moreover, it also assumes that people have capacities for investment (both for equipment and leases), which is less likely to happen for the minorities who did not (and still don't) have access to funds.

All in all, these 3 last types of farms, are the ones that are the most likely to prevent from encroachment, as they use wide areas of pastures. People raising sheep (for cheese production as for meat production), are the ones covering the widest areas thanks to shepherding. Medium family farms for milk production have great economic performances and still use areas for pastures, even though they are smaller.

Discussion

The disappearance of the smaller dairy farms

Most of the family structures for milk and cheese production are endangered. Cheese producers work a lot for low economic results, that does not attract young generations. Side farming is an activity that only interest elderly people who see it as a traditional way of living from former Yugoslavia. They don't have any transferee; their relatives experimenting urban life without side-farming in BiH and abroad. Small farms for milk production are also endangered as their economic results are barely enough for one family with children. They don't attract transferee either. Then, their lands are very likely to be soon managed by bigger farms while the barns and old material would slowly be abandoned.

The disappearance of these farmers could lead to the encroachment of the benchlands, polje bottoms, and intermediary zones. In the dairies' supplies, they are more and more replaced by medium farms, large farms and megafarms for milk production. Only the first ones use these landscape units (while the two lasts work on the benchlands and the few drained arable plots on the polje bottoms). Moreover, the large farms and the megafarms do not meet the BoS requirements for the PGI *Livanjski sir* because of the too high proportion of corn silage in the feeding of their cows. None of the milk producers is involved in the PGI management, done by the dairies. Their cooperation could ensure the quality of the cheeses. Indeed, for now, milk producers were never offered better prices in the name of *Livanjski sir*. Their practices were never discussed in this regard either (most of them aren't aware of the BoS requirements for herd management and feeding practices). The price of the milk only depends on the quantity, which favours the bigger producers – the less susceptible to produce a tasty milk for a qualitative cheese. Dairies could implement price incentives for the producers thanks to whom they are allowed to produce *Livanjski sir,* as a way to promote pastoral practices. A differentiated milk collection route for the farms meeting the BoS requirements would ensure the taste of the *Livanjski sir*. Entering EU – questioning the subsidies and the land management recognition

The least subsidized farms – cheese makers, side-farmers and small farms for milk production – are also the most likely to disappear. Without political impulse, they disappearance is almost ensured. With the entrance program of BiH in EU, production-linked subsidies will be impossible. The subsidies per litter of milk produced, which concerns most farms in the study area, will be replaced by subsidies per managed hectares. Private ownership never exceeds 10 ha of arable lands. Most of the land lease contracts are for public arable lands, which are not equally accessible (the minority of the villages is less likely to obtain leases).

"I'm a small farmer, they favour bigger farms… I sent an application for 45 ha but I don't have answer… It is lasting for 3 years now." (H-Tom-10)

Moreover, private plots tend to stay within family heritage, even if no one maintains them. Not only showing how precarious the access to the lands is for farmers, it also unveils that changes in land management should be done. Documents assessing which farmer use which pastures (*pašnjiak*) and which plots for hay (*livade*) could be implemented for all the production systems. Only the municipalities do it for some public lands used as pastures (the ones enclosed by the farms and the megafarms on cow-veal systems). In EU, alternatives, such as pastoral groups, have been developed to count the hectares pastured by animals on common lands. It would ensure farmers the access to better EU subsidies than if they only applied with their 10 ha of private lands.

Buying land is very difficult. It is a doble constraint for farmers who have no guarantee on the land availability in the following years, and who still struggle with fragmented and small plots.

"*We have 200 ha of land… split between 194 owners!"* (H-Tom-07)

Ownership could help making one bigger plot out of two small ones. To remedy it, a law project on taxing private lands is in progress. People without agricultural activities would have more interest in selling their land rather than simply entrusting it to neighbouring farmers. A side-effect could be the implementation of leases for private lands for hay, which would jeopardise even more small farms for milk production (their income already being low).

The current and coming role of the diaspora

With the daily workload of milking or processing cheeses, side farmers, cheese makers and small farms for milk rely on the family members for mowing. Most of them come back from Western Europe (where they live) for summer holydays. Indeed, diaspora is huge in Canton 10; Livno gets flooded by cars harbouring German plates for summer. The difference is striking in the city: cafés and bars get open and, once school starts again in September, diaspora tourism stops and the atmosphere feels empty.

"The village flourishes with people during summer… when children come back from Germany" (H-Tom-04)

Today, this behaviour is common and strong, but will it still be the case in a few decades? Will it stay the same when there won't be any grand-parent or relative to visit? These movements may evolve into mass tourism, sightseeing and consuming but not for helping at the family farm. The development of tourism around wild horses illustrates this situation. On the one side, they have a negative impact on cheese makers that they force to flee their pastures on karst plateaus – horses frighten sheep around water ponds and are too numerous for water resources of the area.

"There are problems with horses and quads also. People leave salt to attract the horses, for the tourists… and horses come, they eat all the grass around and the sheep can't eat… there is nothing left for them" (H-Liv-01

On the other hand, cheese makers rely on diaspora and tourism markets for selling their cheeses (which is mainly produced in summer). Of the cheese makers interviewed, many said that their clients were mostly acquaintances, people driving through Livno towards Dalmatia and coming back from one year to the other, rather than punctual tourists (more likely to visit Krug to see wild horses). Thus, one can wonder if the wild horses tourism is compensated by the few cheeses bought by daily tourists. Or isn't it leading to the disappearance of traditional cheese makers? In that sense, measures considering the different uses of the karst plateaus could be implemented.

The agricultural employment rate

On the study area, the unemployment rate is high. The megafarms for milk production are hardly replicable because of the lack of available large plots. Thus, even if 44 employees are hired, only a few employments could be implemented through the development of such farms. Of the other types of farms, the ones prone to create the most job opportunities at the scale of the study area are the ones developing on abandoned lands (karst plateaus, intermediary zones, uncultivated polje bottoms). They are ewe-lamb systems, cow-veal systems and medium farms for milk production. If cheese makers were subsidized equally to other farms, new farms could develop and create jobs.

Conclusion

The agricultural lands in the study area

The agrarian landscape of the study area has been shaped by the last socialist regime. The households (~5 cows or ~20 sheep), the cheese producers (~15 cows, ~300 sheep) and the State farms (thousands of animals) were the only three production systems. The partial land confiscation which occurred in the early years of this regime is still a reality today. More than two third of the agricultural lands belong to the state. Indeed, each farmer only owns about 10 ha. On the benchlands (the edges of the karst poljes where the villages are located), lands are split between private and public ownership. Lands in the polje bottom – sometimes drained for growing crops – and pastures on karst plateaus are mostly owned by the state.

The evolution of the farming systems

After Yugoslavia (which was ended in war from 1992 to 1995), the newly established national borders put an end to the main trade market of all the agricultural producers of the area: the Dalmatian coast in Croatia. It took farmers several years to recover from the killing of their animals and the destruction of their farms. The economic situation never reached its past glory – with an important secondary sector – and led to the depopulation of the area, still ongoing. Cheese producers kept on existing, even though their number decreases every day. The formers State farms started to be managed privately but kept their productions systems quite similar: for example, hundreds of cows in stables for milk production or even thousands of cows grazing on wide areas for meat production. These megafarms manage most of the public arable lands, located on the karst poljes. In addition, two waves of installation were noticeable (for newly built farms). The first one was a few years after the war, mainly on cow's milk production. Indeed, some people (mainly minorities who could not get back to their former jobs) had no other choice but to start an agricultural activity for a living. As some of them started implementing silage in their animal feeding, they increase their number of animals and turned into medium family farms (between 20 and 40 dairy cows). The other remained small family farms (with less than 20 cows). Later, after 2010, breeding systems for meat production were created. They benefited from large pasture areas that were not being used because of depopulation. Both sheep and cow production systems developed. As raising cows requires land leases for putting electric fences on public pastures and bigger capacities for investments, only some people could afford it. Even if those two systems are based on the use of pastures, their number is not sufficient for preventing the global encroachment of the karst plateaus. In parallel, large farms for milk production developed, exclusively relying on corn and cereals silage. As they mostly use private plots for growing it, their size can't be as much as the one of the megafarms for cow's milk production, which developed on former State farms lands.

The heterogeneity of the current production systems, especially in dairy productions

Globally, the study area harbours farms which sizes go from 5 cows (70% in the number of farms) to more than 3 000 (less than 1% in the number of farms). Among the milk production systems, the larger ones don't maintain the pastures but uses a lot of lands on the karst polje whereas it's the opposite for the smaller ones. For the meat production systems, only the megafarm for cow-veal system have a consequent number of public plots (to produce winter feeding) on the karst polje, in addition to the pastures.

The gap in the economic results between the different production systems is huge and worsened by the subsidies' repartition. Indee, as they are given on the quantity of milk produced, the more the cows produce and the more animals one farm has, the more subsidies it will get. It goes over 2,6 million KM/year (1,3 million €) for the megafarm producing cow's milk – over 95% of the agricultural income. Because of the new border with Croatia, farmers cannot sell their product at

a good price and the production of cheeses is barely a way of bettering this situation. Indeed, the selling price doesn't pay the higher quantity of work, and the labelling of *Livanjski izvorni sir* as a PDO is more a decoy than a real opportunity. On the contrary, half the dairies of the study area are gathered for the certification of *Livanjski sir* as a PGI. Thanks to it, they can process most of the milk produced on the study area. However, because no difference is made between farm of their collecting routes, some requirements on the animal feeding are not met. Moreover, most of their supply rely on side-farmers (30% of the milk production). As they are slowly disappearing (because most side farmers are retirees) and to prevent milk scarcity, dairies currently develop their own farms.

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Annexes

Annex 1: Interview guideline farmer historical interview

Name interviewer	Name interviewed	GPS location	Code	Date Time	context	translator

1. Presentation

2 students in agriculture, from France – final internship to graduate – trying to understand what farmers do in the area and how it evolved – here for 4 months (until September) – already 2 weeks strolling around to discover agricultural landscapes

We are trying to understand the evolution of agricultural practices, how it used to be and how it is now in the region (canton). And also how agriculture shaped the landscape (with grazing for example).

Do you have some time to discuss with us now?

As we don't speak the local language, there a translator with us and he/she will translate your answers and our questions.

Note: important to date events (death of family members, weddings, birth of child, war, ...)

2. History of the interviewed

What about you? Are (or have you been) a farmer? How many animals do/did you have? How many ha? Are these animals raised for milk, cheese, or meat?
How do you feed your animals? Do you bring animals to summer pastures? Are they in the polje during winter (maybe inside)? Do animals travel long distances according to seasons? What type of pastures: private property, common land? Did it change over the last years (more private land?)? Are there some places where you are not going anymore because there are still mines? Do you have to pay something or give a part of your production?
Do you grow vegetables (potatoes, subsistence farming)? Do you have fruit trees (parents' heritage)? And cereals?
Do you irrigate or drain? Did it change over the years?
Were your parents farmers? How many hectares did they have? How many animals? Could you tell us how farming evolved here?

3. Evolution of population

How did the number of farms evolve? What are they doing (type of production)?
Do people have their own farm and also work somewhere else (if yes, which type of job)? Importance of family farming/subsistence farming?
How did the number of hectares/farms evolve (bigger farms today)?
Are there a lot of uncultivated spaces? More than before (or maybe less)? Why? (because young people go to cities, war memories / new investors...?)
What animals and how many per family? Was it for ploughing? What about now?
How do people feed their animals: silage, fodder, pasture, ...? How did pasture evolve (more forests today, no more pastures on the mountains)?
Is it common to grow their own vegetables? Or do people usually buy it from somewhere else (within canton 10, BiH, Croatia)?
Do people irrigate or drain / have irrigated or drained? Did it change?

4. Cheese production

Cheese production? What people do with milk (beverage, cheese, cream, …)? Transformation on-farm or by village/municipality? Are dairies important to people?
Has it always been like this?
Have you heard about the PGI and PDO?

5. Information

Do you know people who could tell us about history (old farmers)? Can we come back for another interview about your practices?
Can we have your phone number? Email address?
Presentation of our work at the beginning of September (maybe end of August), would you be interested? Probably in Livno but we'll think about organization and let you know.

Annex 2: Interview guideline production system interview

Name interviewer	Name interviewed	GPS location	Code	Date heure	context	translator

1. Brief description

What do you do? What crops / animals do you have? How many ha? What type of land tenure (private property, rental)? Number of parcels? Where are they located (localisation on map – Mergin Map)? Do you have to walk/go by car for long distances between 2 parcels?
How many people work here? Does your family help you? What amount do you keep for your family and what goes for selling?

2. Breeding system

Do you have animals for meat or for milk? What breed?
Herd demography: How many animals in total? How many dams / sires? When do dams have their first born? How many calves / lambs / kids per dam? Do you sell them or raise them (proportions)? How old are they when you sell them? How long do they stay with their dam? How many do you keep for turnover? How many calves / lambs / kids die per year? How many dams die per year? How many dams do you kill per year? How old are they?
Do you buy heifers?
How much do you sell culled dams? How much do you sell calves / lambs / kids?
Do you buy sires? Do you use artificial inseminations? Do you use hormonal synchronizations?
Meat: Do you slaughter them on-farm? Do you go to the slaughterhouse, which one? How long does it take to get there? How much is it to slaughter a cow/a sheep? How many kilos/age do the animals weigh when you kill them?
How much are you subsidized per head of cattle?
Care: Do you use vaccines/antibiotics? Are there diseases? How much do you spend for vet services per year? Tomislavgrad: how much are you subsidized? For what?
Feeding & lodging: Do all the animals stay together all year long or do you have different herds? For each herd: Do they stay in stables? When? What do they eat during this period? How many haybales per winter? How many tons of cereals/silage per winter?
How do you feed calves / lambs / kids kept for turnover?
Where are they when they are not in the stables? Do you bring them hay/straw/silage/cereals when they are outside? How much?

Do you hire shepherds during some periods of the year? If summer pastures, where? Is it state, private or Šumaria land? How far is it (km)? Your own animals or several breeders? How many hours a day? How large is it (ha)? Do you have electric fences?
Do you produce your own animal feed or do you buy it (origin, zone of production)? How much does it cost? How long does it take per day to feed all the animals, with how many people?
Do you cover stable with straw? How often? How long does it take? How many times a year do you clean the stable? How many hours and for how many people? Where do you keep the manure (dump or heap)? How long do you keep it? Do you sell it? To whom?

Milking: How many dams for milking? During what period of the year do you milk them? How do you do it by hand, milking machine, milking stall? How long does it take and with how many people?
Investments for milking machine/parlour?

Milk production: How many litters (total, per dams)? Do you sell your milk raw? To whom? Lactofreeze? How much did it cost? How much are you subsidized per litter of milk?

Cheese production: What type of cheese do you make (cow/sheep milk proportions)? How many litters (% of total milk production)? How many litters of milk for one kilo of cheese? How much time does it take to transform the milk for how many people? Do you do it every day?
How much do you sell your cheeses? To whom? How many people stop by every week? How long does it take per person? Is it only for buying or also for discussing/explaining?
How do you do? Do you use rennet from your animals, which ones? What do you need to buy? Do you use a press (manual one or mechanic one)? Can you show us?
Investments for the cheese-making room? For the press?

3. Cropping system

What crops do you have? How many ha/dulum for each? Rotations: what was on the parcel last year, and the year before? What will you grow on it next year?
How many tractors? How much does it cost to buy a tractor like yours? Lifespan?
Technical operations (for each crop):

- Do you **plough/till**? When? With tractor or motor tiller? How many hours of work, for how many people?
- Do you apply **fertilizers** or **manure**? Where do you prefer to apply manure? Which quantity do you apply?
  Where do you prefer to apply fertilizer? Which fertilizers do you buy? How much do they cost? Which quantity do you apply?
  How many times a year? When? With tractor/hand? How many hours of work, for how many people?
- Is it your own **seeds** or do you buy it? How much do they cost? When do you sow it? With tractor or by hand? How many hours of work, for how many people?
  How much are you subsidized per ha?
- Do you apply **chemicals** (weedkillers, insecticides, pesticides or fungicides)? How much do they cost? How many times a year? How much? When? With tractor? How many hours of work, for how many people?
- Do you **weed**? How many times a year? When? With tractor and sprayer? How many hours of work, for how many people?
- (Do you **drain**? How do you do it? Is it permanent draining? How many hours of work, for how many people?)
- When do you **harvest**? How many hours of work, for how many people? Do you call a contractor? How much does it cost? What are the yields? How many trucks/bags? Where do you store it?
  When do you **mow**? How many times a year (hay)? Small or big haybales? How many bales per ha/dulum? Where do you store it?
  Do you **sell some of** the hay/cereals? How much do you sell it? To whom do you sell it?

4. Subventions

Do you have access to subsidies? From municipality, canton, federation of BiH? What is the amount of your subsidies? Does it represent a big part of your incomes (10%, 50%, 80%)?

Annex 3: Dairy interview guideline

Name interviewer	Name interviewed	GPS location	Code	Date heure	context	translator

1. Presentation

2 master students in agriculture – final internship to graduate – trying to understand what farmers do in the canton – here for 5 months – already 2 weeks strolling around to discover agricultural landscapes.
We are trying to understand agricultural practices, how farming works and what people do in the region. The idea is to have an overview of agriculture in the canton and how it influences the landscape (for example, when pastures are used during the year and where they are located).
We will organize a presentation of our results in September (probably in Livno), and you are welcome to join.

2. Brief description of the dairy products

What type of cheeses do you produce? What type of milk (sheep, cattle, goat)? Where does the milk come from (radius in km)? Do you also buy milk from outside of the canton? How does the milk collect work (specific days during the week, depending on the type of animal: cows on Monday, goats on Wednesday for example)?

3. History of the dairy

Has it always been the same production? Can you tell us the story of the dairy?

(Since when does the dairy exists? Who decided to build it at first (state during socialism, federation, municipality, farmers, ...)?
Are there new dairies (names) or do they tend to disappear? Do you know if breeders go outside of canton to sell their milk?

4. Evolution of cheese production

How did the milk production evolve (in litters) over the last 20-30 years? How did the proportion of goat/cow/sheep milk evolve? Have you been making goat/cow/sheep cheese?
Do you see a difference in the use of pastures? Did the landscape change a lot? Could you describe the main changes you saw in the landscape of the region (municipality / canton)?
What about today? Are there more and more farmers, more and more milk produced per animal? Are there "new" breeds (of dairy animals)?
Does animal feeding have an impact on the taste of cheese?

(Would you say that pastures grazing makes better cheese quality? Is there a lot of farmers feeding their animals with corn? Does it have an impact on cheese taste?)

5. PGI *Livanjski sir*

Do you make cheese under PGI Livansjki sir? Does it represent a big part of your production (in %)? Since when? Where you part of the association that wrote the BoS? Can you tell us why you decided to create this GI?
Do you know anything about the PDO *Livanjski sir*?

If nice feeling: Can you briefly show us how the dairy works (main steps of cheese-making process/ use of different rooms)?

6. Personal information

Email address / phone number

Annex 4: Municipality task officer interview guideline

Name interviewer	Name interviewed	GPS location	Code	Date heure	context	translator

7. Presentation

2 master students in agriculture – final internship to graduate – trying to understand what farmers do in the canton (Livno, Glamoc, Tomislavgrad, Kupres, Grahovo) – here for 4 months – already 3 weeks strolling around to discover agricultural landscapes, having some interviews with farmers, dairies, municipalities, …
We are trying to understand agricultural practices, how farming works and what people do in the region. The idea is to have an overview of agriculture in the canton and its evolution, how it has shaped the landscape (for example, when pastures are used during the year and where they are located, how they changed over the last 40 years).
As you probably know, we already had an appointment with the Ministry for Agriculture, Water Management and Forestry (Bozo Perić and Ivana Misković) of the canton and they organized an appointment with you.
We will organize a presentation of our results in September (probably in Livno), and you are welcome to join. We have the support of the French embassy for this, and from the canton.

8. About interviewed

What is your role in the municipality?

9. Current municipality activities

What are the main agricultural activities? How many farmers? How do you advise them (workshops, topics, …)?
Do you have slaughterhouses, dairies, processing units? Is there a green market? What is its importance on local consumption?

Agricultural statistics (number of farms, their production, land uses, number of animals, etc…)

10. **Municipality subsidy**

Do you give subsidies? Where does the money come from (federation or canton level)? Does it have an impact on how you use it? How to apply for the subsidies?
How do you manage the subsidies in your municipality? Do you only support farms? Which farms do you support (subsistence farming, bigger farmers)? How much do you give (per animal, per hectare, per litter of milk, per farm, …)?
Do you subsidise *Livanjski sir* (PGI and/or PDO)?

Amount of subsidy given to farmers.

11. Livanjski sir / Kupres sir

Do you know the number of farmers selling milk to the dairies? Making their own cheese for selling?
For Kupres: Do you know why the limits of the production area of *Livanjski sir* splits Kupres municipality in two parts? Were you part of the PGI building process?
We saw there is a project for the creation of a PGI on Kupres sir, who is in charge of that (dairies, farmers, …)? Who started the project? What is the state of the project right now?

12. Land use

What are the different land tenures (private property, state property, other)?
Do you manage some land properties? How can people buy lands? Do you always agree on transactions between people?

Land tenure diversity. Number of hectares per farmers. Land registry.

13. Previous municipality activities

Could you tell us about the history of agriculture in the municipality (over the last 40/50 years)?
What were the main agricultural activities after WW2? How did agriculture evolve with Tito, after Tito?
What type of farms stayed after Bosnian war? How did the number of farmers evolve? How did the landscape (forests, cultivated fields, pastures) change in your municipality?

Agricultural statistics (number of farms, their production, land uses, number of animals, etc…)

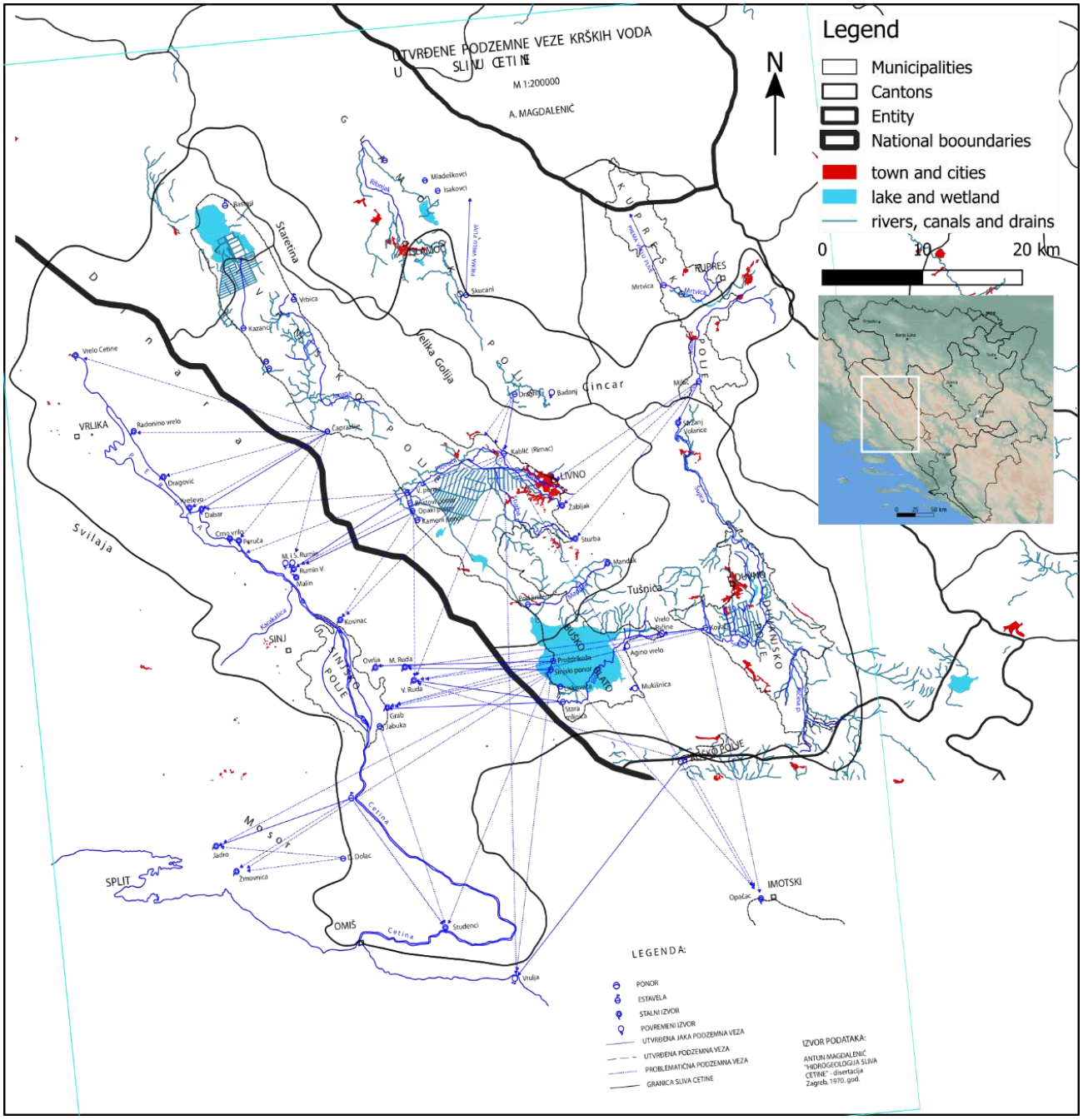
When did mechanisation occur? Do people rely on more chemical inputs? Do they grow the same crops (wheat and barley, variety)?
Do they rely more on feed not produced by themselves? Do they buy a lot of feed from outside of FBiH or from other countries (importations)?
Do people go to pastures the same way as 20 years ago?

14. Personal information

Email address / phone number

Annex 5:Hydrological network of Livanjsko pole

This figure is the superposition of (1) the Yugoslav map of underground connections of karst waters of the Cetina catchment basin made in Zagreb in 1970 by A. Magdalenić and (2) the contemporary georeferenced data of surface waters (lakes, wetlands, rivers, canals).

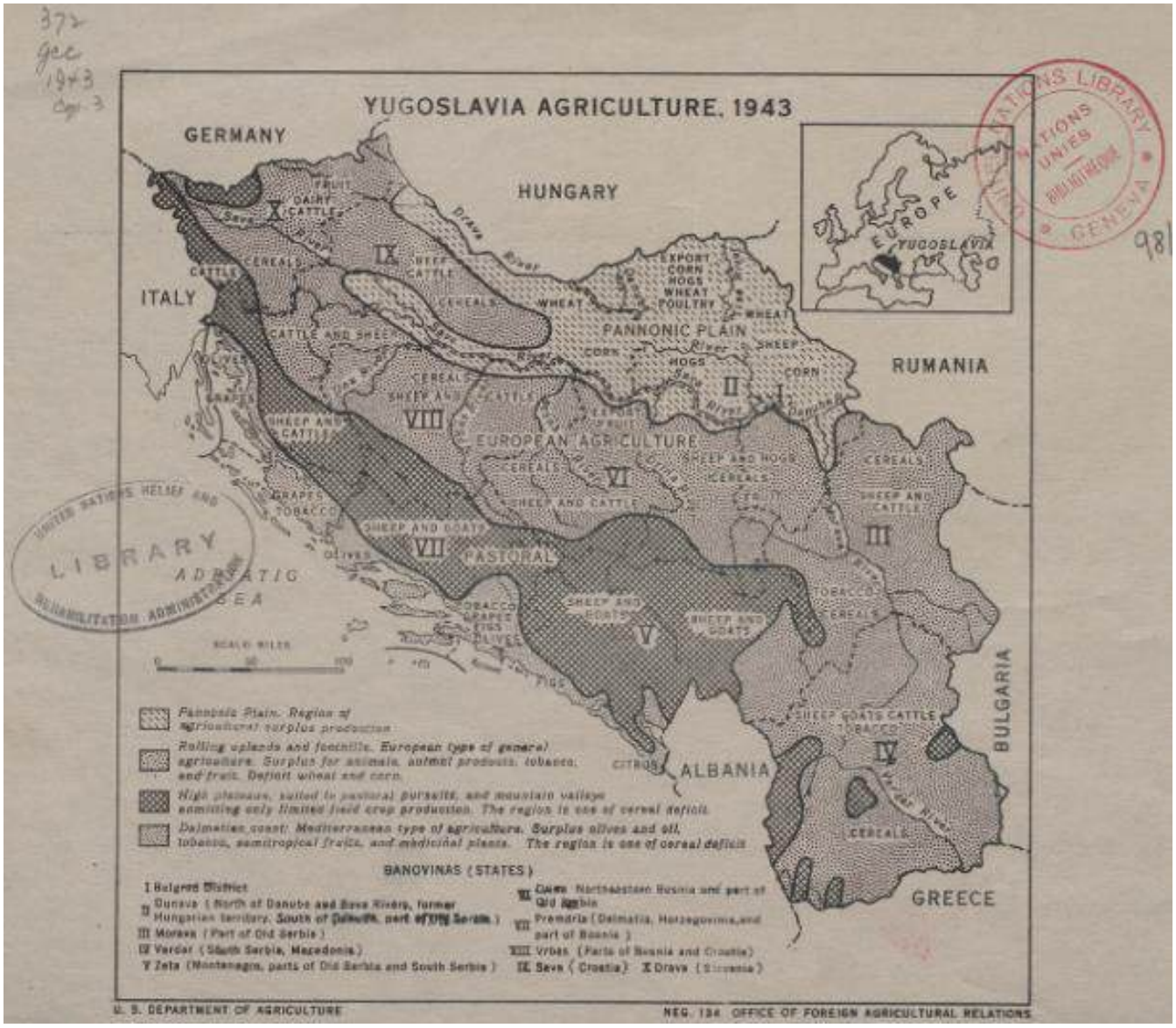


Legend:
utvrđene podzemne veze krških voda u slivu cetine: underground connections of karst waters of the Cetina catchment basin; ponor: ponor; estavela: estavelle; stalni izvor: permanent source; povremeni izvor: occasional source; utvrđena jaka podzemna veza: confirmed important underground connection; utvrđena podzemna veza: confirmed underground connection; problematična podzemna veza: underground connection to be confirmed; granica sliva Cetina: boundary of the Cetina watershed.

Annex 6: Land repartition over Kupres and Livno municipalities.

	Public (State lands)		Private	
	ha	**%**	**ha**	**%**
Oranice (arable lands)	4,414	25%	12,943	75%
Livade (hay & pastures)	13,005	43%	17,214	57%
Pasnjaci (pastures)	55,168	83%	10,977	17%
Total	**72,588**	**64%**	**41,134**	**27%**

Annex 7: Yugoslavia agriculture in 1943. Vienna university.



Annex 8: FBiH subsidies. Source : https://fmpvs.gov.ba/ , 25/09/2024 10h16.

Incentive	Main criteria	Amount for legal person (physical person)
Livestock production		
Cow milk	Min. 500, max. 500,000 L/month	0.42 KM/L (0.40)
Sheep/goat milk	Min. 300, max. 300,000 L/year Min. 25 goats or 50 ewes	0.8 KM/L (0.6)
Breeding heifers	1st calving between 14-26 months	700 KM/heifer (0)
Breeding goat	Min. 25, max. 1300 adult goat	70 KM/adults (35)
Breeding sheep	Min. 50, max. 1300 adult sheep	70 KM/adults (35)
Cow-calf system	Min. 15, max. 600 cows	700 KM/adults (500)
Fattening calves	150 to 249 days Min. 3, max. 600 cows[13]	300 KM/head
Fattening calves	More than 250 days Min. 3, max. 600 cows[14]	300 KM/head
Pig fattening	Min. 25, max. 6000 cows[15]	
Crop production		
Corn for silage, peas, vetch, DTS	Min. 1, max. 200 ha	500 KM/ha (400)
Grains (wheat, rye, corn, triticale, barley, oats)	Min. 2, max. 200 ha	500 KM/ha (500)
Fruits	Min. 0.5, max. 250 ha	500 KM/ha (0)
Investments[16]		
Agricultural machinery / buildings	-	Up to 50% of the cost
Breeding livestock	Buying animals from legal entities	Up to 50% of the cost
Establishment of perennial plantations	-	Up to 50% of the cost

[13] If imported animals: Min. 10, max. 400 cows.
[14] If imported animals: Min. 10, max. 400 cows.
[15] If imported animals: Min. 75 pigs.
[16] Min. 3 000 KM (physical person); Min. 10 000 KM (legal person); Max. 2 700 000 KM.

Annex 9: Canton 10 subsidies for 2024

Incentive	Criteria	Amount
Dairy cows	Same as FBiH	150 KM/cow
Dairy ewes/goats	Same as FBiH	60 KM/ewe or goat
Cow-veal systems	Same as FBiH	100 KM/cow
Ewe-lamb systems	-	5 KM/lamb
Pig fattening	Max. 3 500 000 KM/year	30 KM/head
Breeding heifer	Physical person not receiving from FBiH Max. 3 heifers	300 KM/cow
Spring sowing	Physical person not receiving from FBiH Max. 1ha	300 KM/ha
On-farm cheeses producers	Being member of the PDO Livanjski izvorni Sir Min. 100 sheep and 3 cows	1666 KM
Co-financing of projects for rural development		Up to 10 000 KM
Support for young farmers		

Annex 10: Municipalities incentives and amounts for 2024

Incentive	Criteria	Amount
Kupres		
Sowing	Min. 1 ha	170 KM/ha
Milk producers (1)	-	0,03 KM/L
Milk producers (2)	Milk sold to local dairies	150 KM/cow
Local dairy	Milk bought by local dairies from local farmers	0,02 KM/L
Beekeeping		
Livno		
Seeds	Bills for seeds, fertilizers, chemicals.	On farmers' bills
Purchase of dairy cows	Max. 3 cows.	1 500 KM/cow
Purchase of dairy goat/sheep	Max. 20 animals.	100 KM/sheep or goat
Investments	Increasing the capital of the farm (barn, solar panels...)	Up to 20 000 KM/farm
Young farmers	-	Up to 10 000 KM/farm
Tomislavgrad		
Seeds	Bills for seeds, fertilizers, chemicals.	on farmers' bills
Vet services		50% of AI
Investments	Construction of agricultural buildings	1 KM/m^2

Credits for maintaining or expanding farms	Loans of 50 000 KM max, less than 10% interests, 5-years term	50% of the interests

Annex 11: Agricultural land values in Canton 10 (ranked from I (best) to VIII (lowest)) and main state-owned lands . Institute za gradevinarstvo "IG", University of Banja Luka