FOODNECTED

Ecological Footprint of goat meat from nomadic pastoralist families in Turkey

March, 2023

Global Footprint Network
Advancing the Science of Sustainability

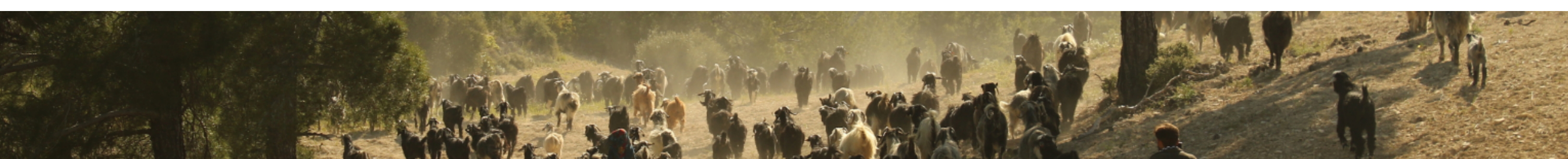
www.footprintnetwork.org

NOTE: *This report has been prepared by Global Footprint Network for the Yolda Initiative in Turkey. The report has been authored by Leopold Wambersie, Maria Serena Mancini, and Alessandro Galli. Gönül Ayça Orhon of Yolda Initiative conducted the fieldwork for collecting the data with the support of Burcu Ateş. We are grateful to Pervin Savran and Oğuzhan Çoban, the Sarıkeçililer Survival and Solidarity Association and Geççi for facilitating the interviews with the nomadic pastoralist families.*

Please cite this report as:
Wambersie L., Mancini M.S., Galli A., Orhon A., Ateş B., and Yilmaz E., 2023. Ecological Footprint of goat meat from nomadic pastoralist families in Turkey. Report on the work commissioned by the Yolda Initiative within the context of the Foodnected project (2021-2022) funded by MAVA.

Contents

1. Introduction 2
2. Overall description of the Ecological Footprint's standard methodology 2
3. The EF methodology applied to goat herding by 14 families of nomadic pastoralists in Turkey 4
3.1. Herd-centric analysis vs. goat-centric analysis 5
3.2. Steps of the herd-centric analysis 7
3.3. Input data and conversion factors used in assessing the Footprints of herds 11
3.3.1. Energy & fuel 11
3.3.2. Purchased feeds 11
3.3.3. Labor/workforce 11
3.3.4. Post-sale Transportation 12
3.3.5. Grazing Footprint of nomadic pastoralism 13
3.4 Ecosystem benefits of the nomadic pastoralism 14
4. Results 17
4.1. Ecological Footprint Analysis 17
4.2. Carbon Footprint Analysis 20
5. Conclusions 21
ANNEX 1 23



1. Introduction

This report – produced within the context of the Foodnected project – assesses the Ecological Footprint of the goat meat produced by 14 families of the Sarıkeçili nomadic pastoralists affiliated/collaborated with the Yolda Initiative in Turkey. Here the standard Footprint methodology is specifically adapted to a bottom-up approach, which is informed by the Life Cycle Assessment (LCA) concept, and which required the collection of data from the 14 families: this data covers the inputs necessary for these nomadic groups to operate and make their outputs available to consumers, and is ultimately used to allocate the Ecological Footprint results to the production – and subsequent consumption – of 1 kg of goat meat.

This document first provides an overview of the standard Ecological Footprint methodology and how it is implemented at the national level to track the consumption of natural resources due to human activities (including pasture and agricultural practices). Then, a detailed explanation of the Ecological Footprint methodology applied to the specific case studies of the 14 nomadic pastoralist families of the Yolda Initiative in Turkey is provided. Finally, the Ecological Footprint results of consuming 1 kg of goat meat produced by the 14 families – as well as an average value – are compared with the average national Footprint value of goat meat consumption in Turkey based on conventional, intensive practices.

2. Overall description of the Ecological Footprint's standard methodology

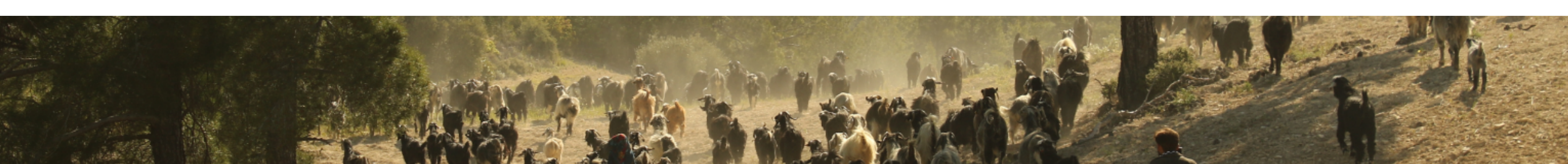
The Ecological Footprint is an environmental accounting tool conceived in the early 1990s by Mathis Wackernagel and William Rees at the University of British Columbia, to account for the human appropriation of the biological regenerative capacity of the biosphere[1] - its capacity to provide life-supporting and regulatory ecosystem products and services.

The standard Ecological Footprint methodology aims at quantifying the demand for (**Ecological Footprint – EF**) and the annual supply of (**Biocapacity – BC**) key provisioning and regulating ecosystem services associated with six main land types (i.e., cropland, grazing land, fishing grounds, forests, carbon Footprint, and built-up land)[2]. It can be applied at scales ranging from individuals to activities and sectors, to cities and regions, and up to countries and the world as a whole. Nevertheless, national-level assessments are often regarded as the most complete.

For a given country, the Ecological Footprint measures the ecological assets (i.e., the biologically productive land and sea areas) required by the population of that country to produce the natural

[1] See Wackernagel, M. and Rees, W.E. 1996. *Our Ecological Footprint: Reducing Human Impact on the Earth*. New Society Publishers, Gabriola Island, BC; see also Wackernagel et al., 1999. National natural capital accounting with the ecological Footprint concept. *Ecological Economics*, 29, 375–390.

[2] See Mancini et al., 2018. Exploring Ecosystem Services assessment through Ecological Footprint Accounting. *Ecosystem Services*, 30, 228-235.



resources and services it consumes. This includes plant-based food and fiber products, livestock and fish products, timber and other forest products, sequestration of waste (CO_2 from fossil fuel burning), and space for urban infrastructure. On the supply side, biocapacity tracks the ecological assets (including forest lands, grazing lands, cropland, fishing grounds and built-up land) available in that country and their productivity[3].

Ecological Footprint and biocapacity thus represent two sides of an ecological balance sheet: if a country's consumption of natural resources and services (i.e., its Footprint) is greater than the capacity of its natural assets to supply them (i.e., its biocapacity), a situation of *ecological deficit* is created. Conversely, if a country's Ecological Footprint is smaller than its biocapacity, this country runs an *ecological reserve.*

Since average biological productivity differs between various land use types, as well as between countries for any given land use type, Ecological Footprint and biocapacity are expressed in mutually exclusive units of world-average bioproductive area calculated through two key coefficients: yield factors (YF) and equivalence factors (EQF). This unit of measure is referred to as global hectare (gha) and allows for comparability across land use types and countries[4].

The most widely used application of Ecological Footprint accounting is the National Footprint Accounts (NFAs), a framework annually published by Global Footprint Network, which provides annual accounts of biocapacity and Ecological Footprint for the world and nearly 200 countries, with historical data reaching back to 1961[5]; each NFAs edition provides updated results for the entire accounting timeline[6].

Within the NFAs, Footprint results do not usually show which economic activities are posing a demand on resources but rather the consequences, in terms of land appropriation, of demanding the outputs of economic activities[2]. Still, attributing the overall demand on nature to particular human activities is essential to be then able to understand our behavior and act for a more sustainable lifestyle. This requires an additional analytical step beyond basic Ecological Footprint accounting[7], and such step is primarily represented by Environmentally Extended Multi-Regional Input-Output Analyses (EE-MRIO)[8].

---

[3] See Galli, A., Wackernagel, M., Iha, K., Lazarus, E., 2014. Ecological Footprint: implications for biodiversity. *Biological Conservation*, 173, 121-132.

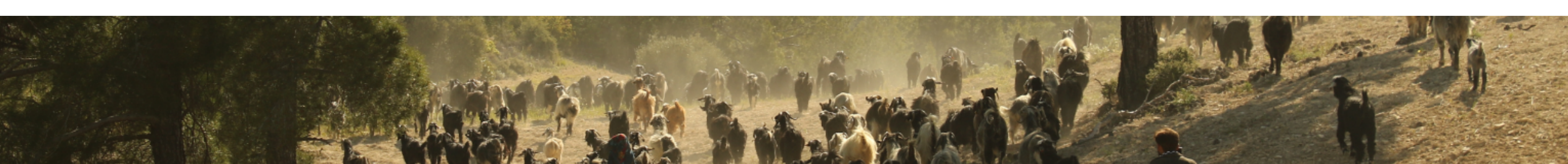
[4] See Borucke et al., 2013. Accounting for demand and supply of the biosphere's regenerative capacity: The National Footprint Accounts' underlying methodology and framework. *Ecological Indicators*, 24, 518–533; see also Galli, 2015. On the rationale and policy usefulness of Ecological Footprint Accounting: The case of Morocco. *Environmental Science & Policy*, 48, 210–224.

[5] National Footprint Accounts (NFA) data for all countries of the world is freely available at: http://data.footprintnetwork.org/#/. This continuously updated framework is based on United Nations (UN) data sets of over 15,000 data points per country and year.

[6] See Lin, D., Hanscom, L., Murthy, A., Galli, A., Evans, M., et al., 2018. Ecological Footprint Accounting for Countries: Updates and Results of the National Footprint Accounts, 2012–2018. *Resources*, 7(3), 58; https://doi.org/10.3390/resources7030058.

[7] Galli, A., Iha, K., Halle, M., El Bilali, H., Grunewald, N., et al. 2017. Mediterranean countries' food consumption and sourcing patterns: An Ecological Footprint viewpoint. *Science of the Total Environment*, 578, 383–391.

[8] See Wiedmann, T., Minx, J., Barrett, J.,Wackernagel, M., 2006. Allocating Ecological Footprints to final consumption categories with input–output analysis. *Ecological Economics* 56 (1), 28–48.



Multi Regional Input-Output (MRIO) tables from the Global Trade Analysis Project (GTAP) database[9] are thus used to translate land-based Ecological Footprint results (meaning results broken down by the land type upon which the Footprint is placed, such as crops, grazing land, etc) into activity-based Ecological Footprint results (meaning results broken down by the human activities responsible for such Footprint, such as food consumption, housing, transportation, etc), thus shifting the debate from where human pressure is being placed to the human activities responsible for such pressures[8]. The outcome of this additional calculation step is called the Consumption Land-Use Matrix (CLUM)[10].

3. The EF methodology applied to goat herding by 14 families of nomadic pastoralists in Turkey

Depending on the scale of application, Ecological Footprint Accounting can adopt either a top-down (compound) or a bottom-up (component) approach. The first approach is most commonly used for Footprint assessments at global and national scales, while the latter is preferred in product- or company-level assessments.

Over the past 10-15 years, several studies have been published dealing with Ecological Footprint assessments at product-level, although only few have focused on agricultural (e.g., tomato[11] and potato cropping[12]), wine[13], and seafood products (e.g., shrimp and tilapia[14], as well as salmon and mussels[15]). More recently, several Carbon Footprint studies have also been published investigating the GHGs emissions associated with agricultural production systems. Although not the first of its kind, the assessment conducted in this report is among the first to be targeted at the practice of nomadic pastoralism. It is applied at the **level of the herd** to quantify both the carbon emissions and the land appropriation due to meat production activities (i.e., their Ecological Footprint).

[9] Global Trade Analysis Project (GTAP 9 Data Base) consists of 57 sectors – 12 of which are agricultural – and includes 140 countries and regions (Narayanan and McDougall, 2015).

[10] See https://www.footprintnetwork.org/resources/mrio/

[11] See Wada, Y., 1993. The Appropriated Carrying Capacity of Tomato Production: Comparing the Ecological Footprints of Hydroponic Greenhouse and Mechanized Field Operations. https://doi.org/10.14288/1.0086320.

[12] See Deumling, D., Wackernagel, M., Monfreda, C., 2003. EATING UP THE earth: HOW SUSTAINABLE FOOD systems shrink our ecological footprint. Agriculture Footprint Brief 12.

[13] Niccolucci, V, Galli, A., Kitzes, J., Pulselli, R.M., Borsa, S., Marchettini, N., 2008. Ecological Footprint Analysis applied to the production of two Italian wines. *Agriculture, Ecosystems and Environment*, 128, 162-166.

[14] Kautsky, N., Berg, H., Folke, C., Larsson, J., Troell, M., 1997. Ecological footprint for assessment of resource use and development limitations in shrimp and tilapia aquaculture. *Aquacult. Res.* 28 (10), 753–766. https://doi.org/10.1046/j.1365-2109.1997.00940.x.

[15] Tyedmers, P.H., 2000. Salmon and Sustainability: the Biophysical Cost of Producing Salmon through the Commercial Salmon Fishery and the Intensive Salmon Culture Industry. https://doi.org/10.14288/1.0099686.

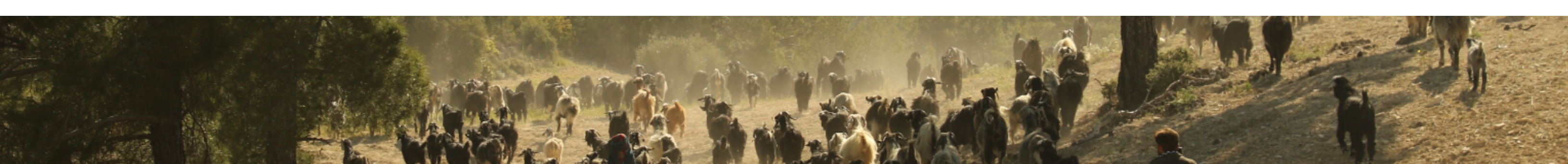
3.1. Herd-centric analysis vs. goat-centric analysis

In assessing the Ecological Footprint of goat meat production by the 14 families participating in the initiative, a bottom-up component approach to Footprint accounting is adopted here. This requires the definition of system boundaries and the use of surveys to collect herd- and family-specific data.

Setting the system boundaries can be accomplished via two different approaches: a “herd-centric” or a “goat-centric” analysis. The goat-centric analysis uses a single animal as the key functional unit. It requires an assessment of all the main phases that allow an individual goat to be raised to the point where it is transported to the slaughterhouse. This analysis requires a lot of specific data that is difficult to acquire, which is why the herd-centric option was used. This is in line with a previous application of the Ecological Footprint to beef production in Menorca[16] as part of the Foodnected project.

Instead of a single animal, the “herd-centric” approach defines the boundary of the system as the entire herd, including the family which manages the herd (Figure 1). As such, all inputs necessary to manage the herd are first quantified – each of them placing pressure on different land types (i.e., ecosystems) – and, once the Ecological Footprint of the whole herd is calculated, it is compared to the quantity of goat meat sold by the family in a given year to calculate the Ecological Footprint associated with 1 kg of goat meat sold to consumers.

[16] Global Footprint Network, 2021, Ecological Footprint of beef products from small-holder farms of Menorca’s Custòdia Agrària programme.



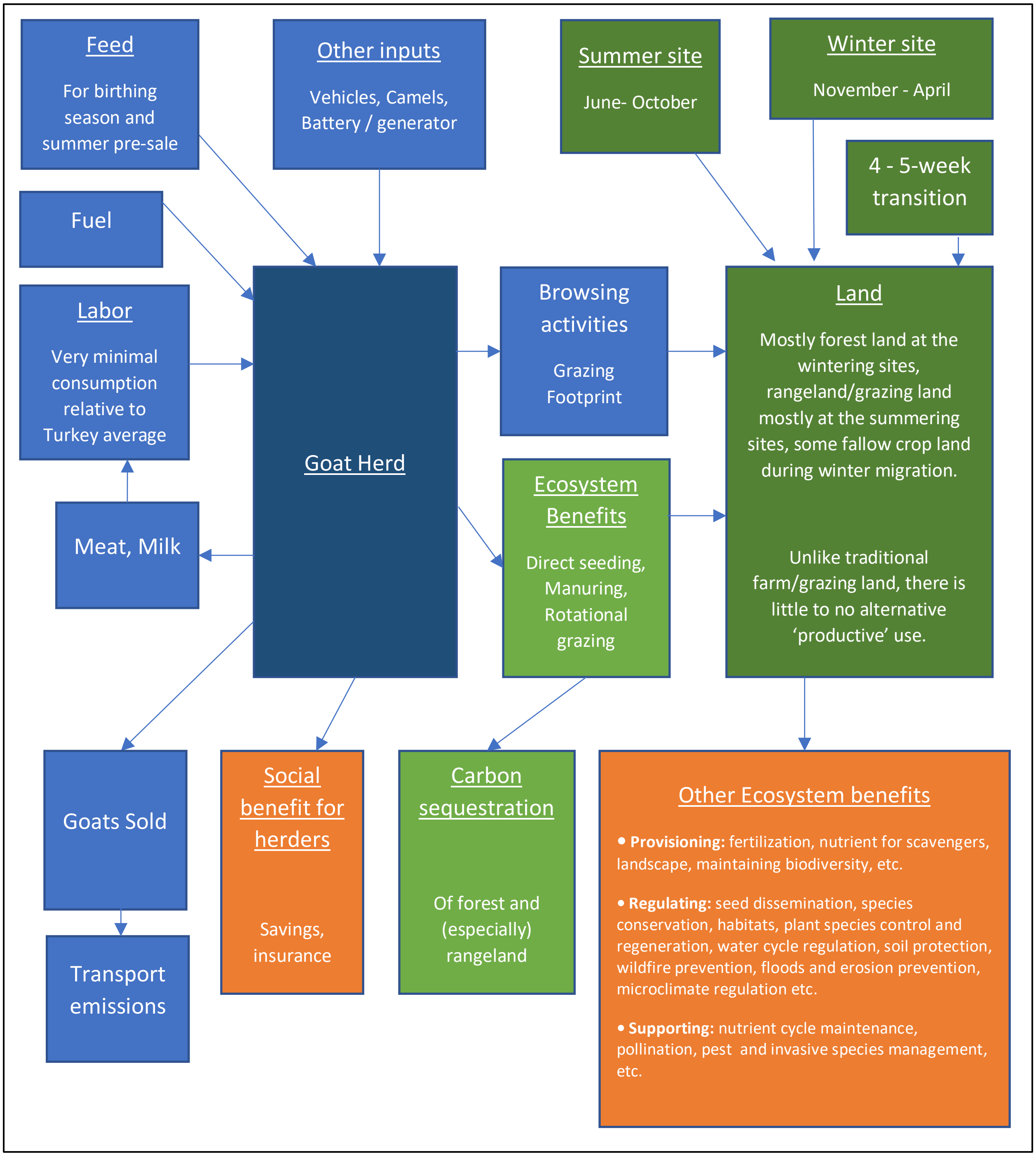
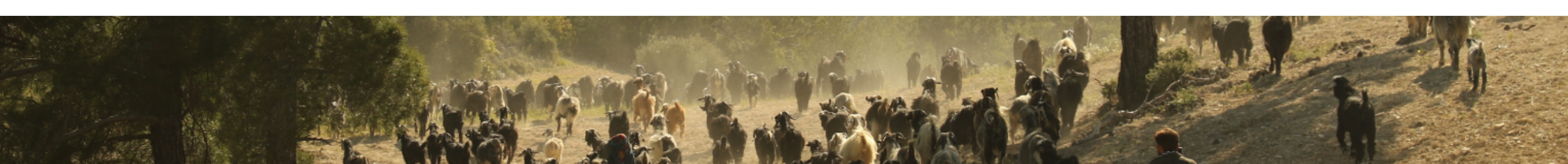


*Figure 1. Diagram of the herd-centric approach for the Footprint assessment. The portion of the system in **blue** represents the quantifiable inputs and outputs that the analysis presented in this report focuses on. The **green** portion of the system concerns the browsing land and associated social and ecosystem services. The ecosystem benefits in the light green boxes are included in the Footprint analysis, while benefits in the orange boxes could not be effectively quantified and were thus omitted from the analysis.*



3.2. Steps of the herd-centric analysis

The Ecological Footprint assessment of goats adopted the herd-centric approach. Each of the 14 families involved in the project was analysed separately, and data collection was thus conducted for each one of them.

For the first step of the analysis, herders were asked to fill an ad-hoc survey, which was developed by Global Footprint Network researchers in consultation with experts from the Yolda Initiative and distributed to the 14 families by Yolda Initiative staff in collaboration with the Sarıkeçililer Survival and Solidarity Association and Geççi in March 2022. Surveys were filled by the herding families with the support – when necessary – of Yolda Initiative staff. Once data was received at Global Footprint Network, it was scrutinized for quality and reliability and, when needed, double checked with the families. An overview of the 14 families and their key characteristics is provided in Table 1, while the full list of survey questions is reported in Annex 1.

A Footprint calculation workbook was then created to assess both the Ecological Footprint associated with each input and that associated with the ecological benefits (e.g., contribution to soil carbon sequestration) provided by the herds; values from these two components were then summed, and finally allocated to the final functional unit of the Footprint analysis: 1 kg of goat, final product weight (see Figure 2). The analysis also provided an average Footprint value across the 14 families – given the variation between them – and a comparison of such average value with the average Ecological Footprint of 1 kg of goat meat, conventionally produced in Turkey.

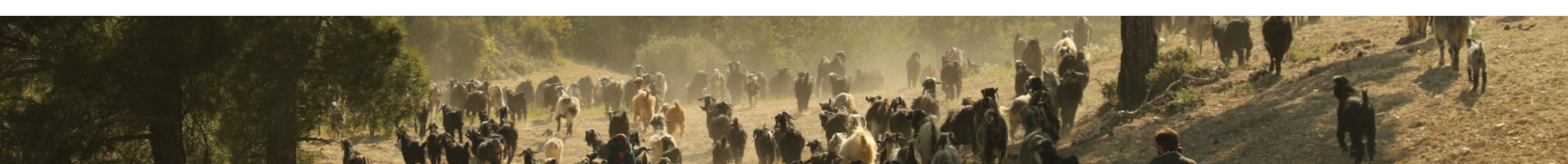
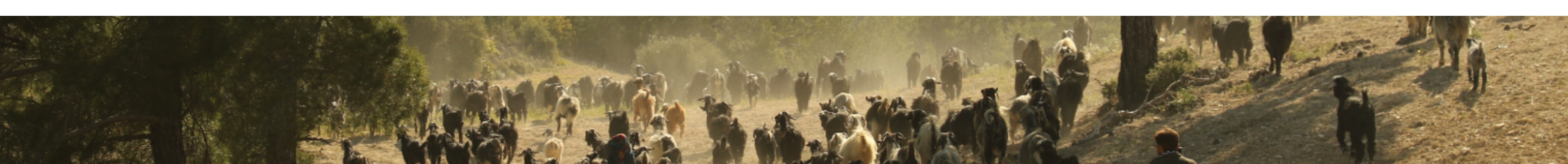


Table 1: Description of the 14 families analyzed in the project.

Family	Number of Goats sold	Number of adults in the family	Quantity (in kg) of additional	Notes
1	200	2	25,000	- Summer site (14 weeks): Ladik / Sarayönü/ Konya - Area of summer site: no data - Winter site (26 weeks): Akdere / Silifke / Mersin - Area of winter site: no data - Family using same summer pasture for 5 years. They use the same winter range for the last 15 years.
2	140	2	50,000	- Summer site (15 weeks): Ladik / Sarayönü / Konya - Area of summer site: no data - Winter site (23 weeks): Akdere / Silifke / Mersin - Area of winter site: no data - Family using same summer pasture for 10 years.
3	160	2	6,000	- Summer site (16 weeks): Taşkent / Konya - Winter site (25 weeks): Hacıbahattin / Aydıncık / Mersin - The family has been utilizing the same summer pasture for the last 10-15 years. They use the same winter range for the last 20-25 years.
4	245	6	45,000	- Summer site (22 weeks): Taşkent / Konya - Area of summer site: no exact data but known that it is larger than the winter pasture and it is administered by the local municipality rather than Forestry DG - Winter site (24 weeks): Hacıbahattin / Aydıncık / Mersin - Area of winter site: 1 sq km - The family has been utilizing the same summer pasture for the last 7 years. They use the same winter range for the last 21 years.
5	30	2	7,000	- Summer site (20 weeks): Başyayla / Taşkent / Konya - Area of summer site: 1.21 sq km - Winter site (16 weeks): Aydıncık / Mersin - Area of winter site: 0.87 sq km - Herders do not tend to consume self-produced food products such as cheese or meat. - The same wintering land is used for 21 years. - The family has two summer pasture locations.
6	280	3	20,000	- Summer site (18 weeks): Seydişehir / Konya - Area of summer site: 1.47 sq km - Winter site (20 weeks): Eskiyürük / Aydıncık / Mersin - Area of winter site: 1.76 sq km - The family has been utilizing the same summer pasture for the last 9 - 10 years. Due to the wildfire in 2021, the area that they used as winter range for 5 years was totaly burned. This is their first year in the new wintering site.
7	300	3	19,000	- Summer site (20 weeks): Seydişehir / Konya - Area of summer site: 6.52 sq km (shared) - Winter site (22 weeks): Hacıbahattin / Aydıncık / Mersin - Area of winter site: 3.25 sq km - The family has been utilizing the same summer pasture for the last 10 years. They use the same winter range for the last 40 years .

Family	Number of Goats sold	Number of adults in the family	Quantity (in kg) of additional feed	- Notes
8	160	2	25,000	- Summer site (21 weeks): Seydişehir / Konya - Area of summer site: 6.52 sq km (shared) - Winter site (22 weeks): Hacıbahattin / Aydıncık / Mersin - Area of winter site: 0.96 sq km - The family has been utilizing the same summer pasture for the last 10 years. They use the same winter range for the last 30 years.
9	180	2	15,000	- Summer site (15 weeks): Çat /Seydişehir / Konya - Area of summer site: no data - Winter site (22 weeks): Hacıbahattin / Aydıncık / Mersin - Area of winter site: no data - The family has been utilizing the same summer pasture for the last 10 years. They use the same winter range for the last 13 years .
10	240	2	32,000	- Summer site (18 weeks): Eşenler / Hadim / Konya - Area of summer site: 4.11 sq km - Winter site (15 weeks): Beydili/ Gülnar / Mersin - Area of winter site: 2.39 sq km - The family has been utilizing the same summer pasture for the last 8 years. They use the same winter range for the last 5 years .
11	255	4	7,000	- Summer site (17 weeks): Afşar-Çumra / Bozkır / Konya - Area of summer site: 6.92 sq km - Winter site (25 weeks): Hacıbahattin / Aydıncık / Mersin - Area of winter site: 2.8 sq km - The family has been utilizing the same summer pasture for the last 7 years. They use the same winter range for the last 20 years
12	1200	17	72,500	- Summer site (15 weeks): Kadınhanı / Ilgın / Konya - Area of summer site: 10.8 sq km - Winter site (22 weeks): Koçaşlı /Gülnar / Mersin - Area of winter site: 8.2 sq km - Largest herd, both in terms of # of goats sold, and number of adults working.
13	200	3	32,000	- Summer site (22 weeks): Sarıoğlan Yaylası/ Bozkır / Konya - Area of summer site: 9.53 sq km - Winter site (18 weeks): Karagöl (pembecik) / Tekeli (bozyazı) / Mersin - Area of winter site: 8.52 sq km - The family has been utilizing the same summer pasture for the last 4 years. They use the same winter range for the last 14 years .
14	700	7	100,000	- Summer site (18 weeks): Seydişehir / Konya - Area of summer site: 32.6 sq km - Winter site (19 weeks): Karadere / Aydıncık / Mersin - Area of winter site: 12 sq km - The family has been utilizing the same summer pasture for the last 20 years. They use a different pasture in each winter period



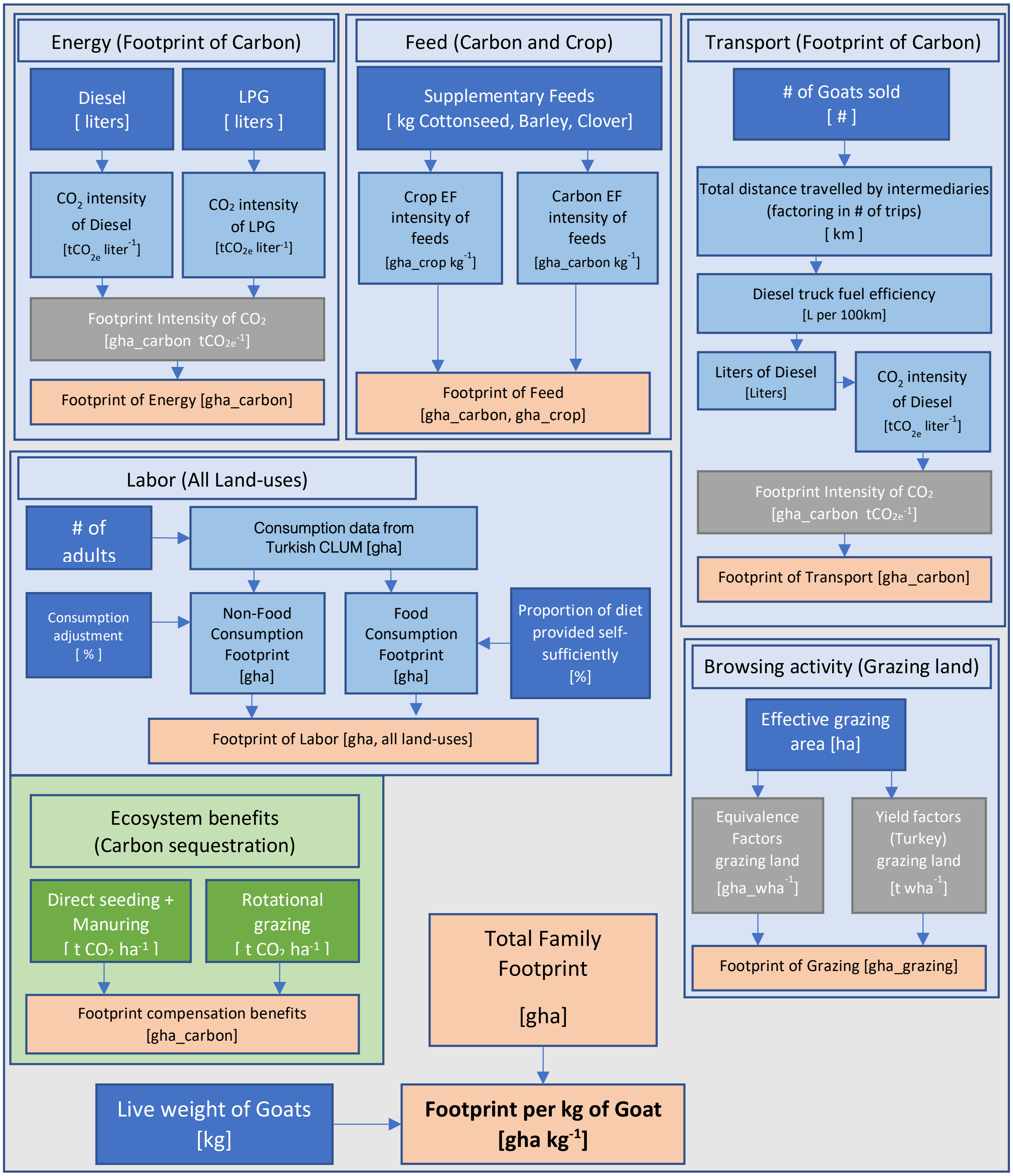


Figure 2: Conceptual overview of the calculation.

3.3. Input data and conversion factors used in assessing the Footprints of herds

3.3.1. Energy & fuel

The constants listed in the table below were used to convert reported consumption of electricity and fuels into the carbon component of the Ecological Footprint.

Table 2. Summary of energy & fuel constants

Constant	Unit	Value	Source
Footprint Intensity of Carbon	[gha_{carbon} (t CO_2)$^{-1}$]	3.42E-01	GFN Turkey Country Workbook
Footprint intensity of Diesel	[gha_{carbon} liter^{-1}]	9.15E-04	EIA Carbon Dioxide Emissions Coefficients by Fuel: https://www.eia.gov/environment/emissions/co2_vol_mass.php
Footprint intensity of LPG	[gha_{carbon} liter^{-1}]	5.13E-04	EIA Carbon Dioxide Emissions Coefficients by Fuel: https://www.eia.gov/environment/emissions/co2_vol_mass.php

3.3.2. Purchased feeds

The constants listed in the table below were used to convert reported consumption of supplementary feeds into the carbon and crop components of the Ecological Footprint.

Table 3. Summary of feed intensities

EF Intensity of feeds	Unit	Value	Source
Cottonseed	[gha_{crop} kg^{-1}]	3.48E-04	Turkey 2018 Workbook - crop_efi_efe
Cottonseed	[gha_{carbon} kg^{-1}]	1.48E-04	Turkey 2018 Workbook - carbon_efi_efe
Barley and Products	[gha_{crop} kg^{-1}]	7.19E-04	Turkey 2018 Workbook - market_feed_supply_n
Barley unmilled	[gha_{carbon} kg^{-1}]	7.93E-05	Turkey 2018 Workbook - carbon_efi_efe
Clover for forage and silage	[gha_{crop} kg^{-1}]	7.60E-05	World 2013 workbook - grass_supply_n
Hay & fodder,green or dry	[gha_{carbon} kg^{-1}]	7.55E-05	Turkey 2018 Workbook - carbon_efi_efe
IYF to compare 2013 Clover with 2018	NA	0.953	FAOSTAT

3.3.3. Labor/workforce

The human labor necessary for the functioning of a herd is part of the herd's Ecological Footprint. To estimate this value for the nomadic pastoralists, we build on the consumption Footprint of the

average Turkish consumer and adjust it as explained here below. The per capita Ecological Footprint value of an average Turkish person drawn from the Turkish national CLUM available in Global Footprint Network's internal database is multiplied by the reported number of full-time equivalent workers. Both adult members of the families and children aged 15 years or older (who have herd-related tasks) are counted as "workforce", leaving children younger than 15 years old out of the calculation.

Two adjustments are then made: Firstly, a proportion of the Ecological Footprint of consuming food (hereafter food Footprint) is subtracted from the total Footprint value, reflecting the self-sufficient nature of herder's diets when it comes to meat and dairy (at least for most – although not all – of the families). This value is based on survey responses, which report both the proportion of the daily diet that is self-provided, and the specific food groups being produced. A second adjustment is made to the non-food portion of the Ecological Footprint of an average Turkish person, to reflect the fact that nomadic pastoralists necessarily consume relatively little outside of the bare necessities (especially when compared with an average Turkish inhabitant). The non-food portion of the CLUM is therefore reduced by a factor of 50%.

3.3.4. Post-sale Transportation

The calculation of the Ecological Footprint associated with the transport of goats (hereafter transportation Footprint) by the intermediaries after their purchase was based on the reported distance of each intermediary in km, as well as the estimated number of trips necessary (based on # of goats sold) and the average fuel efficiency of Diesel trucks. The Footprint associated with pre-sale transportation activities (e.g., families' use of Diesel and LPG for moving around and for generators in their tents) is already included as part of the Footprint associated with each family's own fuel consumption. The Footprint associated with the transportation of purchased feeds could not be included due to insufficient data about the origin of the feed, indicating that the Footprint of transportation is likely an underestimate.

Table 4. Constants used for assessment of transportation footprint

Constant	Unit	Value	Source
CO2 Intensity of transportation	[$kgCO_2\ kg^{-1} km^{-1}$]	0.0001197	Global Footprint Network's Eco-tourism project https://www.mdpi.com/2079-9276/7/2/38
Diesel truck fuel economy	[L per 100 km]	20.0	Based on an average value for rigid truck, regional delivery, typical payload www.researchgate.net/publication/318642247_Fuel_efficiency_technology_in_European_heavy-duty_vehicles_Baseline_and_potential_for_the_2020-2030_timeframe

3.3.5. Grazing Footprint of nomadic pastoralism

The grazing Footprint refers to the “appropriation” of land for the browsing activities of the goats, which eat the vegetation in place as their main source of food. Conventional production of goat meat is very intensive in terms of the human pressure continuously placed on the grazing land (i.e., grazing Footprint) through the seasons. Conversely, the browsing activities of nomadic pastoralist herds take place on different grounds depending on the season: from the Mediterranean shores (Mersin province) in winter to mountain grounds (Taurus mountains and beyond) in summer[17]. As such, each family of the Sarıkeçili nomadic pastoralists spends a different number of weeks (depending on the seasonal changes) on a given pasture site before then migrating (transit period taking a few weeks) to the next site for the following season. Moreover, the presence of browsing herds, not only places a demand on the grazing land capacities to produce edible biomass but also contributes to bringing to the pasture ecosystems various environmental benefits (e.g., soil carbon sequestration). The procedure adopted to quantify the grazing land Footprint is thus described here below, while the benefits brought by the browsing activities – and how they are assessed in terms of “Footprint benefits” – are described in section 3.4.

Since territories are used for a limited time during the year in the nomadic practices, the ‘effective grazing area’ was calculated for each family, considering summer and winter sites and excluding the migration routes (transit area) due to their high variability. The Effective Grazing Area was calculated as follows:

1. A goat density (in terms of goats per km^2) was calculated for those families who had provided data on the size of summer and winter pasture sites. Then, the average area per goat was derived across all families and between the two seasons and applied to all families (0.0075 km^2/goat).
2. The area used is then calculated by multiplying the average area per goat by the number of animals owned by each family. The value so obtained is compared with that provided in the survey responses (if known by the respondents), and the minimum value among the two is selected to avoid overestimation of the grazing/browsing area.
3. The resulting summer and winter areas are then averaged, with weights representing the % of the year spent at each site, to obtain an area – the effective grazing area – representative of a whole year’s activity.

The grazing Footprint is then calculated by multiplying the effective grazing area per each family, by the yield factor for Turkey and the equivalence factor of grazing land (see Borucke et al., 2013).

[17] The seasonal territories are owned by the government and mainly left unmanaged with any type of alternative uses, such as agriculture or construction, legally permitted. In terms of ecosystems and types of vegetation, there can be forests (mostly in the wintering sites) as well as pastures and rangelands made of bushes and shrubs, in which the herd is free to browse. Migration routes are instead very mixed in terms of ecosystems and land uses, going from bare lands to cultivated areas owned by others.

Table 5. Constant for the grazing Footprint

Constant	Unit	Value	Source
Yield factor of grazing land	[t wha^{-1}]	1.32	National Footprint Account 2022 edition, Turkey workbook
EQF	[gha wha^{-1}]	0.45	National Footprint Account 2022 edition

3.4 Ecosystem benefits of the nomadic pastoralism

Nomadic pastoralism is a traditional cultural practice that benefits both biodiversity and the human wellbeing of communities living in Turkey. Although little knowledge has been published on this specific matter, the benefits that nomadic pastoralism practice provides to ecosystems are multiple: carbon sequestration, biodiversity conservation and protection of land and ecosystems (UNEP, 2017[18]); pastoral landscapes have the potential to achieve a neutral carbon balance, as grazing can offset carbon levels by stimulating plant growth, which helps sequester carbon in soil (FAO, 2021[19]). Moreover, herds can also be moved to fallow lands and fields to make use of crop residues for feed and to distribute animal manure as fertilizer – recycling nutrients as part of a circular bioeconomy (FAO, 2021). Finally, pastoralism contributes to food and water security, as it provides affordable, high-quality proteins and nutrients to meet local demand and can help reduce a country's reliance on imports (UNEP, 2017; FAO, 2021). More generally, pastoralists effectively manage natural resources and landscapes, helping preserve biodiversity and the health of pastoral ecosystems, which otherwise would be lost.

Following the above, an attempt has been here made to provide a first estimation of the Ecological Footprint compensation benefits associated with the nomadic pastoralism practices, which can counterbalance the Ecological Footprint the nomadic families exert on the planet due to their activities. As such, including such benefits into the overall assessment has allowed to provide an estimate of the net Ecological Footprint of the nomadic pastoralism, thus balancing positive and negative impacts. The environmental benefits considered in the analysis are those that could be translated in Ecological Footprint terms through suitable conversion factors found in literature. Specifically, the practices included in this analysis are rotational grazing, direct seeding and manuring:

- **Rotational Grazing**: rotational grazing is the practice of frequently rotating herds between multiple paddocks to allow grazed areas to rest and the plants therein to recover. This practice applies to the nomadic pastoralism on the seasonal area, as herds are constantly moved around on different portions of the pasture sites. Rotational grazing can improve

[18] Available at: https://www.unep.org/news-and-stories/story/towards-sustainable-pastoralism#:~:text=Sustainable%20pastoralism%2C%20which%20is%20centred,protection%20of%20land%20and%20ecosystems.

[19] Available at: https://www.fao.org/fao-stories/article/en/c/1453839/

soil health, increase forage productivity, and improve animal health. Studies have found that rotational grazing can effectively reduce soil erosion and, thus, increase soil organic carbon stocks (Mosier et al., 2021[20]; Conant et al., 2003[21]; Rowntree et al., 2020[22]).

- **Direct seeding**: it refers to the dispersal of forage seeds in native pastures without tilling the soil. Direct seeding minimizes soil disturbance, thus reducing erosion, increasing soil organic matter, and improving soil health (Yang et al., 2013[23], Francaviglia et al., 2017[24]). As for the pastoralism in Turkey, the nomadic goats – by moving around – carry in their stomach (and release via their feces) and on furs and hooves, seeds of many different plants, contributing to the spreading of the genetic resources of these plants, contributing to an increase in the plant richness of grazing areas and, ultimately to the increase in the organic carbon stored in the soil.

- **Manuring**: In conventional livestock production systems, manure is often a large source of greenhouse gas emissions, namely in the form of methane and nitrous oxide. For this reason, adopting more sustainable manure management practices help reduce emissions at the farm level. Studies have found that various manure management practices (e.g., spreading manure on crops) can improve soil health and productivity, increase soil organic carbon (SOC) stocks, and reduce nitrous oxide and methane emissions (Xia et al., 2017[25]; Curien et al., 2021[26]). However, the effects may vary significantly depending on a number of factors, including how manure is stored (i.e., in a solid or liquid state), the temperature and climate conditions, the animals' diets, and the amount and rate of spreading on crops (Petersen et al., 2013[27]; Curien et al., 2021).

[20] Mosier, S., Apfelbaum, S., Byck, P., Calderon, F., Teague, R., Thompson, R., & Cotrufo, F. (2021). Adaptive multi-paddock grazing enhances soil carbon and nitrogen stocks and stabilization through mineral association in southeastern U.S. grazing lands. Journal of Environmental Management, 288. Available at: https://www.sciencedirect.com/science/article/pii/S0301479721004710

[21] Conant, R. T., Six, J., & Paustian, K. (2003). Land use effects on soil carbon fractions in the southeastern United States. I. Management-intensive versus extensive grazing. Biology and fertility of soils, 38, 386-392.

[22] Rowntree, J. E., Stanley, P. L., Maciel, I. C., Thorbecke, M., Rosenzweig, S. T., Hancock, D. W., ... & Raven, M. R. (2020). Ecosystem impacts and productive capacity of a multi-species pastured livestock system. Frontiers in Sustainable Food Systems, 4, 232.

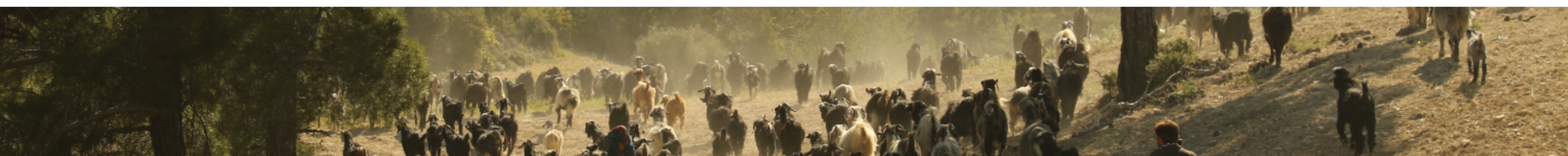
[23] Yang, X., Drury, C.F., & Wander, M.M. (2013). A wide view of no-tillage practices and soil organic carbon sequestration. Acta Agriculturae Scandinavica, 63, 6. https://doi.org/10.1080/09064710.2013.816363

[24] Francaviglia, R., Di Bene, C., Farina, R., & Salvati, L. (2017). Soil organic carbon sequestration and tillage systems in the Mediterranean Basin: a data mining approach. Nutrient Cycling in Agroecosystems, 107, 125-137.

[25] Xia, L., Lam, S. K., Yan, X., & Chen, D. (2017). How does recycling of livestock manure in agroecosystems affect crop productivity, reactive nitrogen losses, and soil carbon balance?. *Environmental Science & Technology*, *51*(13), 7450-7457.

[26] Curien, M., Issanchou, A., Degan, F., Manneville, V., Saby, N. P., & Dupraz, P. (2021). Spreading herbivore manure in livestock farms increases soil carbon content, while granivore manure decreases it. *Agronomy for Sustainable Development*, *41*, 1-13.

[27] Petersen, S. O., Blanchard, M., Chadwick, D., Del Prado, A., Edouard, N., Mosquera, J., & Sommer, S. G. (2013). Manure management for greenhouse gas mitigation. *Animal*, *7*(s2), 266-282.



These three practices could be considered in the analysis as they contribute to carbon sequestration, which in turn can be translated into an Ecological Footprint “compensation” benefit. With the help of experts from Yolda initiative, a literature review was conducted to identify suitable conversion factors estimating the amount of soil carbon sequestration associated with the three practices applied to nomadic pastoralism.

As specific studies referring to rotational grazing, direct seeding and manuring associated with nomadic goats are not available in the literature, a study from Mosier et al (2021) for the carbon sequestration rate of rotational grazing was used, alongside 3 studies (Schuman et al., 2002[28], Arca et al., 2021[29] and Escribano et al., 2020[30]) dealing with the carbon sequestration rate of direct seeding and manuring, which in this study are combined due to lack of information of the specific practices used in each family. The smallest value of carbon sequestration (see Table 6) was then chosen to be as conservative as possible.

Since these factors refer to soil organic carbon sequestration per unit of area, they were multiplied by the size of the Effective Grazing Area used by each family (see section 2.3.5) thus allowing to calculate the environmental benefits, in terms of carbon sequestration, for each herd based on the number of goats.

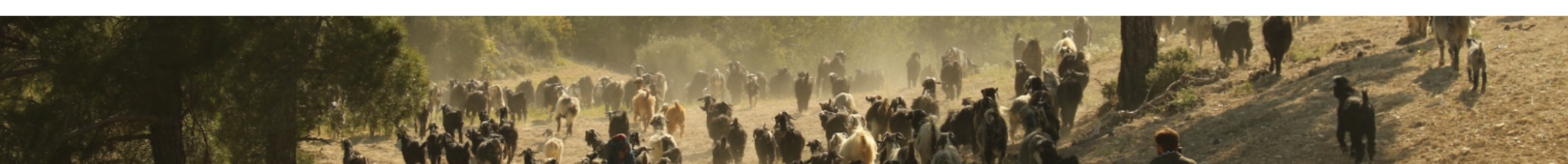
Table 6. Carbon sequestration factors of environmental benefits.

Environmental benefit	Constant	Unit	Value	Source
Direct seeding + manuring	Carbon sequestration rate #1	[t C ha^{-1} yr^{-1}] [t CO_2 ha^{-1} yr^{-1}]	0.3 1.101	Schuman et al., 2001
	Carbon sequestration #2	[t CO_2 ha^{-1} yr^{-1}]	0.793	Arca et al., 2021
	Carbon Sequestration #3 (selected value in the analysis)	**[t CO_2 ha^{-1} yr^{-1}]**	**0.3565**	**Escribano et al., 2020**
Rotational grazing	Carbon sequestration	[t C ha^{-1} yr^{-1}]	0.51	Mosier et al., 2021

[28] Schuman G.E., Janzen H.H., Herrick J.E. (2002) Soil carbon dynamics and potential carbon sequestration by rangelands, Environ. Pollut. 116, 391–396.

[29] Arca, P., Vagnoni, E., Duce, P., & Franca, A. (2021). How does soil carbon sequestration affect greenhouse gas emissions from a sheep farming system? Results of a life cycle assessment case study. Italian Journal of Agronomy, 16(3).

[30] Escribano, M., Elghannam, A., & Mesias, F. J. (2020). Dairy sheep farms in semi-arid rangelands: A carbon footprint dilemma between intensification and land-based grazing. *Land use policy*, *95*, 104600.



4. Results

4.1. Ecological Footprint Analysis

Figures 3 shows the Ecological Footprint results from the analysis conducted at family level, thus expressed as overall Footprint impact of each family for pasturing their own herd of goats.

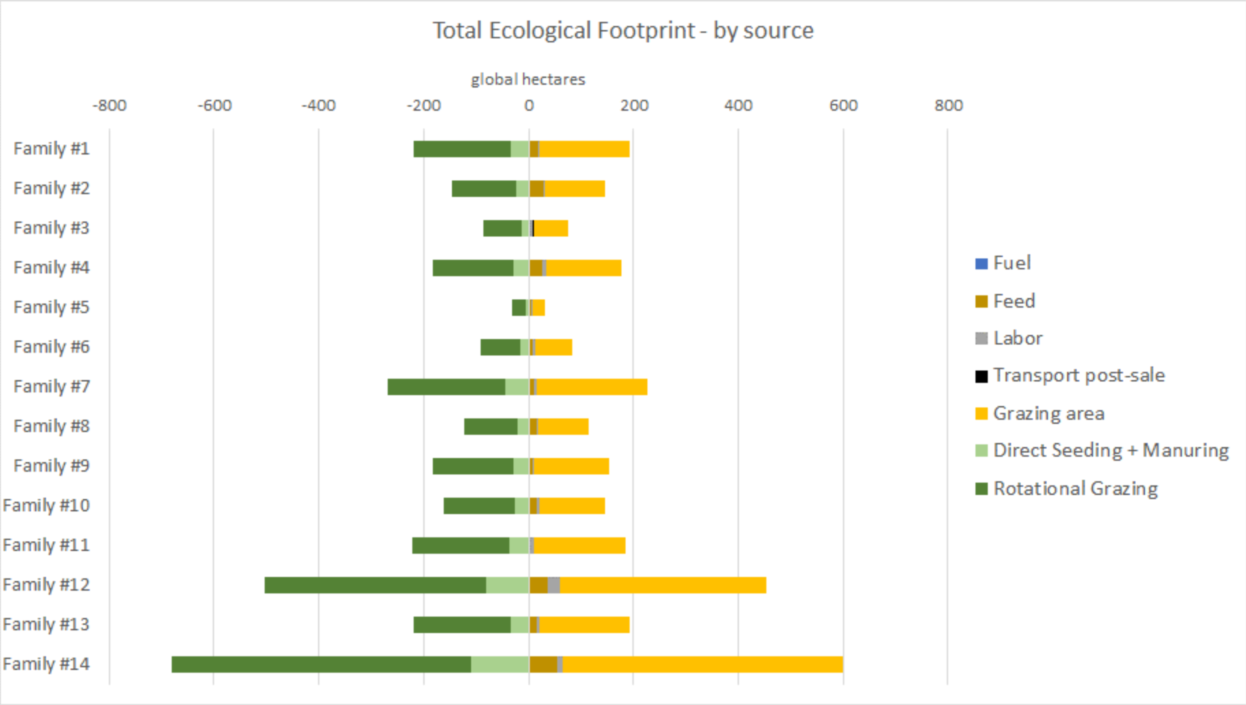


Figure 3. Total Ecological Footprint of each herd in global hectares, broken down by its source.

When excluding the Footprint compensation benefits due to direct seeding, manuring and rotational grazing, the Ecological Footprint of yearly managing each family' herd varies from 32 gha (family #5) to 600 gha (family #14); however when the benefits to the ecosystem are factored in the calculation, the net Footprint results range from -81 gha (family #14) to +1.3 gha (family #5), with only two families (family #5 and family #2), ending up consuming slightly more resources and ecological services than the ecosystems benefits their herds supply.

These overall results provide an indication of the total resource demand of each family, given their specific number of goats in a specific year, and can be useful for families to understand the overall impacts (and benefits) of their herd on the ecosystems. However, since there is significant variation among families and in different years in the number of goats, as well as in the inputs needed to manage the heard, this type of results cannot be used for comparison among families, nor across different years for the same family.

Total Ecological Footprint results are thus allocated to the production of 1 kg of goat meat produced by each family (see Figure 4), and compared with the average value of all families as well as with the national Turkish value of producing goat meat through conventional practices.

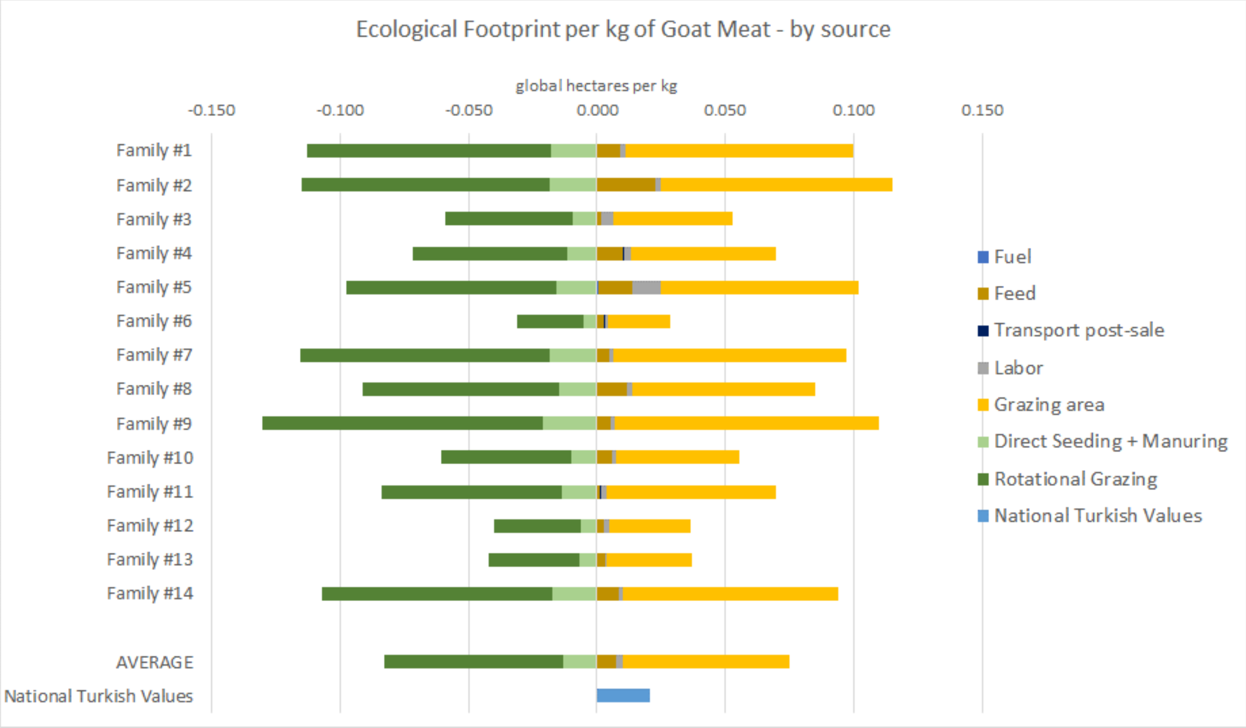


Figure 4. Ecological Footprint allocated to 1 kg of goat meat from each herd, broken down by the source of the Footprint.

The Ecological Footprint results per kg of goat meat range from -0.0207 gha (family #9) to 0.0042 gha (family #5), corresponding to -207 gm^2 and 42 global square meters (gm^2) of appropriated bioproductive land, respectively.

The average Footprint of 1 kg of goat meat from the 14 families is found to be -0.0075 gha, equivalent to about -75 global square meters (gm^2). This means that raising goats via nomadic pastoralism practices brings more benefits to the ecosystems (in hectare equivalents) than the resources and ecosystems services it demands from the ecosystems, through the entire year and all grounds they pasture on.

Two (#2 and #5) of the 14 families are found to have a Footprint value higher than zero: family #2 has a Footprint of 0.0005 gha kg^{-1} – corresponding to 5 gm^2 – as the sum of the resources demand is 0.1153 gha kg^{-1} while the sum of benefits is -0.1148 gha kg^{-1}. For this family, we can thus assume that resources' demand is almost entirely balanced by the benefits provided by the herd. Meanwhile, Family #5 has a net Footprint of 0.0042 gha (or 42 gm^2) worth of resources and ecological services needed to produce and make available to the market 1 kg of goat meat for consumers' use. The reason for these results is likely due to the relatively low number of goats sold by these families (350 and 77 for Family #2 and #5 respectively) compared to the other families.

When compared to the national average goat meat production, results indicate that for the nomadic pastoralists to produce a kg of goat meat (-75 gm^2) requires about **135% less** Ecological

Footprint than if the meat were produced conventionally in Turkey (209 gm^2). The national average figure is calculated using the overall grazing Footprint of goat meat production in Turkey drawn from GFN's National Footprint Accounts combined with data on national goat meat production (a total of 69,925 tons per year)[31], as well as the non-grazing Footprints associated with average meat consumption in Turkey[32]. This large difference between the national average and the value calculated for the nomadic pastoralists likely stems from the fact that nomadic pastoralism brings multiple environmental benefits to the ecosystems, contrary to the conventionally raised goats that intensively pasture on rangelands. Specifically, this analysis could effectively track the improved potential of carbon sequestration of soils thanks to the rotational grazing - contributing 84% of the total benefits - and the direct seeding practices (16% of the total benefits).

When looking at the Footprint drivers and the land types upon which the highest pressure is placed (see Figure 5), the area "appropriated" for browsing is found to contribute the most, on average 86% of the overall goat meat Footprint, which corresponds entirely to the Footprint of grazing land. The second driver is the purchased feed contributing approximately 10% of the overall goat meat Footprint. Of this feed Footprint, approximately 80% is the Footprint placed on cropland, and the remaining 20% is the demand placed on the planet's carbon sequestration capacity. Finally, 4% of the goat Footprint is due to human labor, while fuel use and transportation have a negligible share of the overall Footprint (<1%).

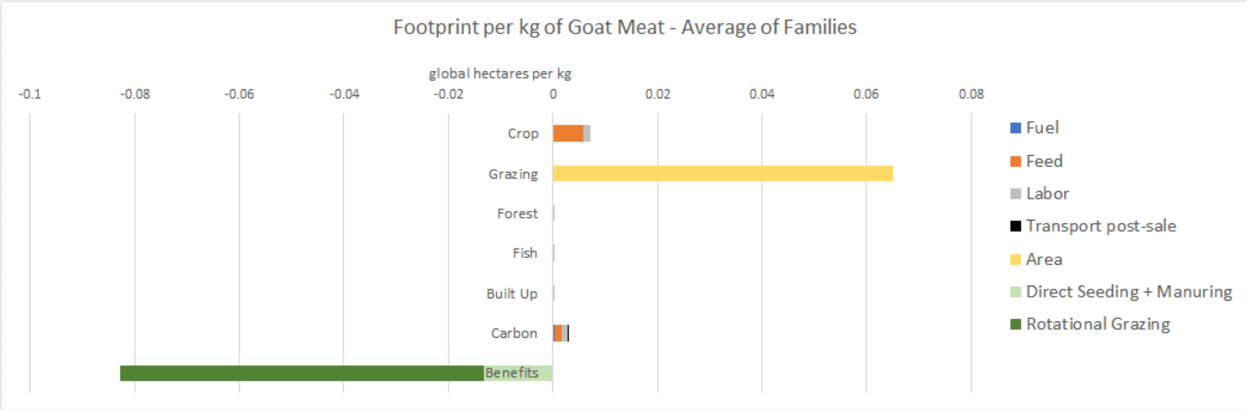


Figure 5. Average Ecological Footprint of consuming 1 kg of goat meat, broken down by both land-types and inputs.

If goat meat were produced worldwide via traditional nomadic pastoralism practices like those of the Sarıkeçili nomadic pastoralists of the Taurus mountains, it would move Earth Overshoot Day by **2.2 Days**. Further research, however, is needed to be able to assess the feasibility to satisfy the current demand for goat meat via nomadic practices.

---

31 These two figures are drawn from Global Footprint Network's Turkey Workbook for the data year 2018.

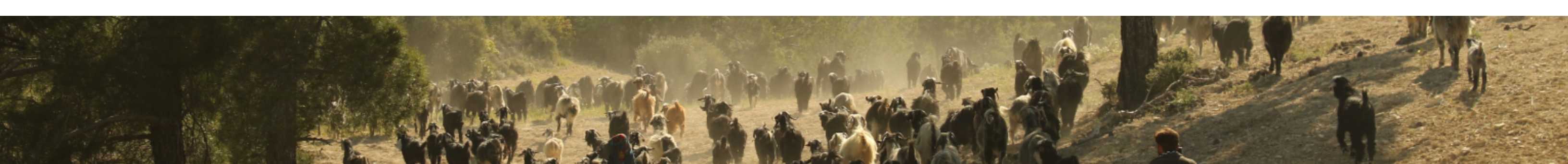
32 This figure is drawn from Global Footprint Network's MRIO database (see https://www.footprintnetwork.org/resources/mrio/). See also https://www.sciencedirect.com/science/article/pii/S0048969716323816.

4.2. Carbon Footprint Analysis

This section presents a secondary analysis focusing exclusively on the Carbon Footprint indicator, intended as the kg of CO_2 equivalent released for 1 kg of meat from each herd. These results represent a subset of the overall Ecological Footprint analysis[33], made by combining input data representing direct emissions (such as those from energy and transportation) before its conversion to global hectares, with the carbon component of the Ecological Footprint associated with other inputs (labor, purchase feeds). This carbon analysis ignores the non-carbon impact of meat production, as well as any connections to the earth's regenerative capacity made possible by measurement in global hectares. However, it has been included because of the recent popularity of carbon accounting and the ability to compare Carbon Footprints across a wide range of products.

Assessing the Carbon Footprint in Figure 6 reveals that producing goat meat via nomadic pastoralism practices and making it available (through the intermediaries) to consumers causes the release of approximately 8.2 kg CO_2 per kg of meat. It also reveals that the energy embodied in the purchased feed is the most significant contributor (51% on average), followed by the consumption activities of the families themselves (Carbon Footprint of labor contributing 40% of the total Carbon Footprint); then 6% on average is due to the fuel use and 2 % to the transportation of post-sale. It should be noted that, opposite to the above Ecological Footprint assessment, Footprint compensation benefits have not been quantified in this analysis.

[33] Please refer to Galli et al., 2012 (see https://www.sciencedirect.com/science/article/abs/pii/ S1470160X11001889) for a comprehensive definition of the differences between the carbon Footprint component of the Ecological Footprint methodology (which refers to the area needed to sequester human induced CO_2 emissions) and the "Carbon Footprint" methodology (which tracks the amount – in kg – of emitted CO_2 and other GHGs).



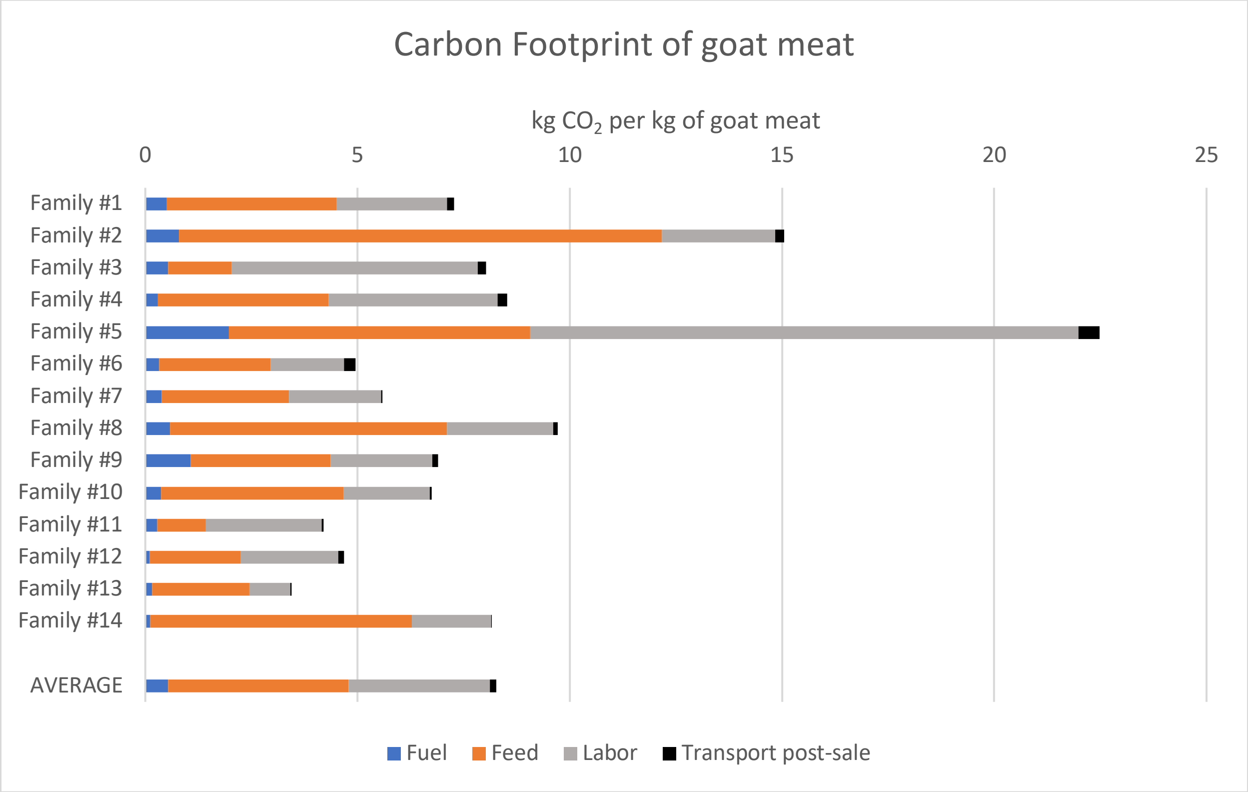


Figure 6. Emissions of CO_2 associated with 1 kg of goat meat from each farm.

5. Conclusions

The analysis of the Ecological Footprint of 14 families in Turkey living as nomadic pastoralists and raising goats to produce meat has shown that the overall demand for resources and ecological services associated with such traditional practice is more than counterbalanced by the environmental benefits brought by the animals on the ecosystems, with a final average Footprint result of -0.0075 gha per kg of goat meat indicating a net benefit. In fact, all but two families result in a net benefit to the environment (ranging from -0.0018 to -0.021 gha kg^{-1}).

Looking at the impacts, the major driver is the occupation of rangelands (86% of the total Footprint), which in Ecological Footprint terms translates into the grazing land appropriated for making the goats browse. Then the purchased feeds contribute as a second driver (10% on average).

As for the environmental benefits, the analysis relied on a few literature studies dealing with various typologies of grazing systems and providing carbon sequestration estimates that could be applied to rotational grazing, direct seeding and manuring practices. The selected values were then applied to the area affected by the browsing activity of each family's herd.

The overall results of net benefits to the environment brought by nomadic pastoralism support the theoretical assessments that pastoralism practice helps achieve a neutral carbon balance on the grounds where it is done, as grazing of animals enhances the carbon sequestration capacity of soils and thus helps offset the carbon emissions (UNEP, 2017; FAO, 2021). Nevertheless, an actual quantification (via direct measurements) of the carbon sequestration and storage on the ground where nomadic pastoralism is practiced would be needed to confirm the empirical results obtained by this analysis.

ANNEX 1

Survey Questions

Answers can be approximated / omitted if unknown

Inputs

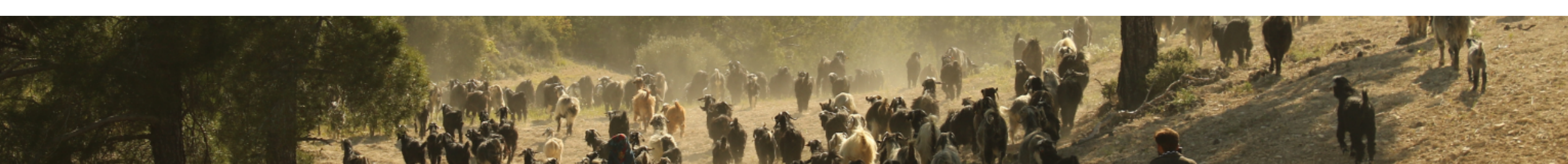
Fuel		
How much fuel is consumed yearly? This includes vehicles, generators.	Diesel Gasoline Natural Gas LPG	[Liters] [Liters] [Liters] [Liters]
Is fuel used for tasks unrelated to herding activities? If so, what proportion?		Type in answer
Feed		
How much additional goat feed is purchased yearly?		[kg]
Type of feed (crop or grass based?)		Type in answer
Is this feed grown locally (within region), or from elsewhere?		[local / imported]
If not local, from where? (if known)		Type in answer

Herd & Sale process

What is the size of the herd (before sale)?	[# of head]
How many goats are sold per year?	[# of head]
What is the approximate live weight of the goats at sale?	[kg]
General description of sale & slaughter process.	Type in answer
Are goats sold as live animals or are they slaughtered?	[live / slaughtered]
Where are goats sold? At the pasture site, or somewhere else?	Type in answer
In which period are the goats sold?	Type in answer
If they are slaughtered, where does this take place?	Type in answer
Approximately what distance are goats transported before and after sale and/or slaughter (if known)	[km]
How are they transported? (specify, if possible, type of vehicle and fuel type)	Type in answer

People

Family		
How many individuals are part of the family?	Adults Children	[#] [#]
Consumption patters		



General description of the family's diet. What items are purchased vs self-produced? i.e. dairy and meat from the goats.		Type in answer
Approximately what proportion of the family's diet is self-produced?		[%]
General description of regular non-food purchases. Vehicles, clothing, electronics, etc.	Monthly Annual	Type in answer Type in answer

Sites		
How many weeks are spent at each site?	Summer Winter Transit	[# of weeks] [# of weeks] [# of weeks]
What is the general location of summer and winter sites? (Geographic description / name of area)	Summer Winter	[location] [location]
What is the general location of the travel corridor between the sites? Is it always the same route?		Type in answer
What is the approximate area of the summer and winter sites? (if known)	Summer Winter	[Square km] [Square km]
Do families go back to the same sites, or do they rotate?		Type in answer
What is the land cover like at the summer and winter sites? Vegetation, Geography.		Type in answer