

CLEANED Documentation

Conceptual overview of CLEANED and parameterisation of a CLEANED tool for Bama, Burkina Faso

February 2018



Prepared by SEI and ILRI on behalf of SAIRLA

CLEANED Documentation: Conceptual overview of CLEANED and parameterisation of a CLEANED tool for Bama, Burkina Faso

February 2018

Authors:

Catherine Pfeifer¹, Joanne Morris², Salifou Ouedraogo³, Jon Ensor²

¹ International Livestock Research Institute (ILRI), Nairobi

² Stockholm Environment Institute (SEI), Environment Department, University of York (UoY)

³ Université Nazi Boni de Bobo-Dioulasso

This project, 'Research and Learning for Sustainable Intensification of Smallholder Livestock Value Chains in Burkina Faso, Ethiopia and Tanzania' (ResLeSS), is part of the Sustainable Intensification of Agricultural Research and Learning in Africa (SAIRLA) Programme. It is led by the Stockholm Environment Institute (SEI), in collaboration with the International Livestock Research Institute (ILRI), Environment and Climate Research Center (ECRC) at Ethiopian Development Research Institute (EDRI), Institut de l'Environnement et de la Recherche Agricole (INERA) and Sokoine University of Agriculture (SUA). The project is working with the CGIAR Livestock CRP Country Coordinators, ICARDA in Ethiopia, and ILRI in Tanzania and Burkina Faso.

Funded by the UK Department of International Development, SAIRLA is a five-year programme (2015 to 2020) that seeks to generate evidence and design tools to enable governments, investors and other key actors to deliver more effective policies and investments in sustainable agricultural intensification (SAI) that strengthen the capacity of poorer farmers', especially women and youth, to access and benefit from SAI in Burkina Faso, Ethiopia, Ghana, Malawi, Tanzania and Zambia. The SAIRLA programme is managed by WYG International Ltd and the Natural Resources Institute, University of Greenwich.

This document was made possible with support from the UK Department for International Development (DFID). The contents are the responsibility of the producing organization and do not reflect the views of UK DFID, the British Government, WYG, nor the University of Greenwich - Natural Resources Institute.




The project thanks all donors and organizations who globally supported its work through their contributions to the CGIAR system.

© 2018



This publication is licensed for use under the Creative Commons Attribution 4.0 International Licence. To view this licence, visit <https://creativecommons.org/licenses/by/4.0>.

Unless otherwise noted, you are free to share (copy and redistribute the material in any medium or format), adapt (remix, transform, and build upon the material) for any purpose, even commercially, under the following conditions:

 **ATTRIBUTION.** The work must be attributed, but not in any way that suggests endorsement by the publisher or the author(s).

Contents

1	Introduction	8
2	Conceptual overview of CLEANED The	8
2.1	conceptual CLEANED tool Interpreting and	8
2.2	using CLEANED outputs	10
	2.2.1 A representation and simplification of the real world	10
	2.2.2 Sensitivity and non-linearities	10
3	CLEANED in Burkina Faso	11
3.1	Boundaries of the study area	11
3.2	Livestock production in Bama	14
	3.2.1 Initial livestock numbers per production category	15
3.3	Seasonality for Burkina Faso	16
3.4	Vignettes – storylines of plausible change	17
3.5	Adjusting the tool to include moving animals Functioning of	18
4	CLEANED tool for Bama	19
5	References	21
6	Appendix	22
6.1	Initial livestock numbers in CLEANED	22
6.2	The full vignette parametrization in CLEANED Valuation of	23
6.3	environmental impact in CLEANED	26
	6.3.1 The developed exploratory scenarios	26
	6.3.2 Assigning the score to changes	29
6.4	Land cover and transhumance zones in CLEANED CLEANED	30
6.5	output for the homogenous stakeholder group scenarios	30
	6.5.1 Other farmers (Green group)	31
	6.5.2 Pastoralists (Blue group)	34
	6.5.3 Meat and milk processors (Yellow group)	37
	6.5.4 Ministry representatives and district administration (Orange group)	40
6.6	CLEANED output for the heterogenous stakeholder group	42
	scenarios	
	6.6.1 Group A : initial scenario	43
	6.6.2 Group A : negotiated scenario	45
	6.6.3 Group B : initial scenario	47
	6.6.4 Group B : negotiated scenarios	48

Acroymns

Acronym	
A1	Agro-pastoral transhumant herd, somewhat improved
ABR	Agro-pastoral transhumant herd, Baseline (current state)
AFSIS	Africa Soil Information Service
CC	Climate Change
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CLEANED	Comprehensive Livestock Environmental Assessment for improved Nutrition, a secured Environment and sustainable Development
CO2	Carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
D1	Specialised Dairy animals, somewhat improved
D2	Specialised Dairy animals, much improved
DBR	Specialised Dairy animals, Baseline (current state)
DFID	UK Department for International Development
DHS	Demographic Health Survey
ECRC/EDRI	Environment and Climate Research Center (ECRC) at Ethiopian Development Research Institute (EDRI)
F1	Fattening animals, somewhat improved
F2	Fattening animals, much improved
FAO	UN Food and Agriculture Organisation
FBR	Fattening animals, Baseline (current state)
GAEZ	Global Agro-ecological Zones
GIS	Geographic Information System
GRAF	Groupe de Recherche et d'Action sur le Foncier
ha	hectares
ICARDA	International Center for Agricultural Research in the Dry Areas
ILRI	International Livestock Research Institute
INERA	Institut de l'Environnement et de la Recherche Agricole
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
l/year	litres per year
L1	Agro-pastoral dairy herd, somewhat improved

L2	Agro-pastoral dairy herd, much improved
LBR	Agro-pastoral dairy herd, Baseline (current state)
LT	Long transhumance
NRI	Natural Resources Institute
OSS	Sahara and Sahel Observatory
ResLeSS	Research and Learning for Sustainable Intensification of Smallholder Livestock Value Chains
SAI	Sustainable Agricultural Intensification
SAIRLA	Sustainable Agricultural Intensification Research and Learning in Africa
SEI	Stockholm Environment Institute
ST	Short transhumance
SUA	Sokoine University of Agriculture
T1	Draft animals, somewhat improved
TBR	Draft animals, Baseline (current state)
UN	United Nations

Executive summary

This companion document provides supporting information about the “Comprehensive Livestock Environmental Assessment for improved Nutrition, a secured Environment and sustainable Development along livestock value chains” (CLEANED) tool and how it has been parameterised for use in Burkina Faso, including a description of the study area. CLEANED is a spatial multi-dimensional and rapid environmental impact assessment framework of livestock value chains. It was developed to identify potential positive and negative environmental impacts of proposed practices or development interventions, and addresses the current gap in environmental assessment methods by being a rapid, multi-dimensional assessment tool including various spatial and temporal scales. For the “Research and Learning for Sustainable Intensification of Smallholder Livestock Value Chains” (ResLeSS) project, CLEANED has been applied in Burkina Faso, Ethiopia and Tanzania.

The CLEANED model focuses on environmental impact of livestock value chains associated with feed production, which constitutes the major source of environmental impacts related to livestock value chains. Environmental impact is categorized into four key impact dimensions that are used as proxies to assess environmental change. Three dimensions, I) water, II) land/soil and III) biodiversity, are impacting the local environment, while the fourth, IV) greenhouse gas (GHG) emissions, is used to assess the contribution to global climate change (CC). The tool uses pixel based modelling with spatial input data to generate output maps showing the distribution of environmental change in relation to baseline conditions. As such the CLEANED tool can be seen as a way to give meaning to the many openly available but difficult to interpret GIS data for the context of transforming livestock value chains.

In Burkina Faso, the focus is cattle production in the zone of Bama commune, Houet province, Burkina Faso. From the first ResLeSS workshop and consultation with local experts, five categories were identified to represent cattle production in Bama: agro-pastoral transhumance herds, agro-pastoral dairy herds, specialised dairy animals, fattening animals and draft animals. To capture the area providing the majority of feed for the Bama cattle, the southern part of Padema commune was included in the study area, as this area is utilised by the majority of the transhumant herds who only go on a small transhumance route that extends to the southern part of Padema and the fringes of other communes neighbouring Bama. Those animals that join the long transhumance route to Ghana and Cote d’Ivoire are considered in CLEANED to leave the study area for the seven months of the year that they are away (December to June), and the impact of their feeding during this time is considered to be external. The feedbasket in Bama is predominantly natural vegetation and crop residues, with some supplementation of planted fodder and agro-industrial by-products such as cotton-seed cake. The composition varies in the wet and dry season, so each production category has a wet and a dry season feedbasket.

Initial livestock population numbers to parameterise the ‘base run’ in CLEANED (a scenario that represent the present day situation) are calculated for the five categories using a triangulation between the participatory GIS activities in the first workshop, freely accessible spatial data layers and household survey and verified against provincial or commune level livestock population statistics from FAO and Burkina Faso. It was also made clear in Workshop 1 that transhumant animals are counted in ‘troupeaux’ (broadly translates to ‘herd’), not in individual animals. Someone using the CLEANED tool (the user) therefore sets the population of the agro-pastoral transhumance herds and agro-pastoral dairy herds in terms of the number of herds, where an agro-pastoral transhumance herd has 120 animals and an agro-pastoral dairy herds has 20 animals.

To make it easy and fast for users to build scenarios of livestock production in Bama (how to produce in each category and how many animals per category) in a workshop setting, a set of ‘vignettes’ was produced that describe credible combinations of feed baskets with animal productivity for each animal category representing two or three different livestock management options within each production category. These vignettes are pre-set within the CLEANED tool code, so that the non-expert can develop credible scenarios.

This document accompanies the report of the second ResLeSS workshop in Bama, Burkina Faso, titled “Exploring alternatives for livestock production in Bama, Burkina Faso: Playing the Transformation Game”, which presents the design and results of the workshop.

1 Introduction

This report is a companion document to the Transformation Game Workshop report for Burkina Faso, which describes the design and outputs of the second workshop in Bama commune, Houet province, Burkina Faso, for the Research and Learning for Sustainable Intensification of Smallholder Livestock Value Chains (ResLeSS) project, which is part of the Sustainable Agricultural Intensification Research and Learning in Africa (SAIRLA) programme, funded by UK DfID and managed by the Natural Resources Institute (NRI) at the University of Greenwich and WYG. The two workshops and a preceding reconnaissance tour form the ResLeSS process, a participatory process designing according to social learning design principles that brings multiple stakeholders together to first consolidate in stakeholder groups their priorities for what a successful livestock future means and should deliver, and then to negotiate in mixed groups how to design scenarios for the future to fulfil all groups' priorities. The ResLeSS process combines using a rapid ex-ante environmental impact assessment tool (CLEANED¹) and a participatory economics approach together with input from local stakeholders, to produce decisions that have taken into account three pillars of sustainability – the environment, economics and equity.

This companion document provides a conceptual overview of the “Comprehensive Livestock Environmental Assessment for improved Nutrition, a secured Environment and sustainable Development along livestock value chains” (CLEANED) tool (Chapter 2). CLEANED was originally developed during 2013-2015, in a collaboration between the Stockholm Environment Institute (SEI), the International Center for Tropical Agriculture (CIAT) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and International Livestock Research Institute (ILRI), funded by Bill & Melinda Gates Foundation.

In the ResLeSS project, CLEANED has been applied in, Burkina Faso, Ethiopia and Tanzania. The conceptual idea of the ResLess project, the ResLeSS process, combines top-down modelling to bottom-up participatory methods in an iterative process of scenario design and evaluation in order to identify trade-offs between different socio-ecological impacts of sustainable intensification, and enhance adaptive capacities to handle these. This report provides details of how CLEANED has been applied and parameterised for use in Burkina Faso, including a description of the study area (Chapter 3).

CLEANED is implemented as an R code, with an RShiny user interface. Basic information about the main functions of the tool and a guide to using the interface are presented in Chapter 4.

2 Conceptual overview of CLEANED

2.1 The conceptual CLEANED tool

CLEANED is a spatial multi-dimensional and rapid environmental impact assessment framework of livestock value chains (Notenbaert et al., 2014). It was developed to address the current gap in environmental assessment methods by being a rapid, multi-dimensional assessment tool including various spatial and temporal scales² (Ran et al., 2015). The tool was developed to identify potential positive and negative environmental impacts of proposed practices or development interventions. The results highlight, in broad terms, the potential level of environmental impacts and identify “hotspots” of environmental impact.

The environmental impact is categorized into four key impact dimensions that are used as proxies to assess environmental change. Three dimensions, I) water, II) land/soil and III) biodiversity, are impacting the local environment, while the fourth, IV) greenhouse gas (GHG) emissions, is used to assess the contribution to global climate change (CC).

The tool uses pixel based modelling with spatial input data to generate output maps showing the distribution of environmental change in relation to baseline conditions. As such the CLEANED tool can be seen as a way

¹ Comprehensive Livestock Environmental Assessment for improved Nutrition, a secured Environment and sustainable Development.

² Fast in terms of developing parameters specific to a new study area, and in comparison to hydrological models, for example, which can require months of intensive fieldwork to calibrate and parameterise.

to give meaning to the many openly available but difficult to interpret GIS data for the context of transforming livestock value chains.

For each of the four environmental dimensions: i) a map illustrates the change between the baseline and the analysed future, and ii) for selected landscape scale indicators results are also presented in the form of a relative change to the baseline, i.e. consumptive water use in a scenario compared to the consumptive water use in the estimation of the current situation (baseline). In addition, measures of change in livestock productivity are also given. It is important to remember that CLEANED assesses relative change, thus the absolute numbers of environmental impacts or productivity change are only indicative.

The CLEANED model focuses on environmental impact of livestock value chains associated with feed production, which constitutes the major source of environmental impacts related to livestock value chains (Steinfeld et al., 2006; Fraval, 2014).

The four environmental impact dimensions are modelled based on the following criteria:

Water use is assessed by calculating crop and grass water requirement for the feed and fodder consumed by the analysed livestock production systems. Because the major water impact is resulting from feed and fodder consumed by the livestock, water impact is computed by comparing the water needed to produce the feed and fodder consumed by the livestock with the annual rainfall. The water needed is based on location specific evapotranspiration for each feed and fodder item. Crop water requirements are obtained from FAO's Global Agro-Ecological Zones (GAEZ) spatial layers of crop-specific actual evapotranspiration for low-input rainfed crops (mm) (GAEZ, 2012). Livestock energy requirement is estimated using equations for net energy requirements for cattle (IPCC, 2006, p10.15-10.18, based on National Research Council, 1996).

Greenhouse gas emission estimates are based on IPCC Tier 2 (IPCC, 2006) methodology and includes emissions from enteric fermentation, manure management, feed and fodder production and land use change for feed and fodder production.

Biodiversity measures are based on the International Union for Conservation of Nature and Natural resources red list of endangered species (IUCN, 2017). A species richness index is computed to show where most endangered species are located allowing to identify biodiversity hotspots. In the case of a land use change, the tool computes how many species that are critically endangered lose a piece of their habitat.

For the soil pathway, the input-output flow of nitrogen is calculated for each pixel, serving as a proxy for soil health based on the assumption that a positive balance (more nitrogen being added to the soil than is being removed) contributes to a healthy soil. The inflow of nitrogen consists of manure and fertilizer that is added to the soil, atmospheric deposition, and biological fixation. The nitrogen output consists of nitrogen absorbed by the feed and fodder, erosion, nitrogen leaching, and gaseous losses.

The CLEANED model is spatially explicit and integrates a range of open access geographical data, namely: evapotranspiration for different crop types, suitability and yields of different crop types and climate data (Global Agro-ecological Zones, GAEZ, <http://www.fao.org/nr/gaez/en/>), various soil related maps (Africa Soil Information Service, AFSIS, <http://africasoils.net/>), land cover (Sahara and Sahel Observatory, OSS, <http://www.oss-online.org/rep-sahel>), greenhouse gas relevant maps (IPCC), making the model easily adjustable to any site.

To be as specific as possible, the input data for CLEANED should preferably be of high resolution and validated for the area of analysis. In particular, the land cover information is of great importance for the model outcome since it determines areas where animal feed and fodder may be produced, thus areas of potential environmental concern. To model future scenarios, land use change can also be modelled in CLEANED. These must be developed individually for each site of analysis and consider local expert knowledge and data to provide relevant data that can be discussed in stakeholder participatory workshops.

A detailed technical manual describing the CLEANED equations will be made available, together with the CLEANED tool for Burkina Faso by early 2019.

To provide useful output, the CLEANED tool has been combined with participatory stakeholder workshops. The participation of local stakeholders is vital to improve the local relevance of the output, both to ensure that

the local context and dynamics are captured correctly in the input to the model and to build credibility and understanding, co-generating knowledge around potential environmental impacts associated with sustainable transformation and aid stakeholders in planning and decision making.

A baseline participatory workshop with identified stakeholders that are representative for the area of analysis was organized to gather input data for existing livestock systems and provide input to the baseline scenario in the CLEANED modelling. This data describes the livestock production systems and agricultural practices dominating the area of interest, and any environmental issues in the area that are currently of concern to the stakeholders, or may be in the future.

The ResLess process

In addition, as part of the ResLeSS process, participatory workshops have been organized to explore the outputs of the tool once parameterised for the area of interest, to validate the results in the context of local expert knowledge of systems that are not captured in the model, such as market networks and socio-economic conditions. Stakeholders can then explore trade-offs and synergies implied by different interventions and build consensus for a desirable future. In such an exercise, stakeholders compare and adjust the scale and mode of future livestock production systems and agricultural practices to meet various demands, which include environment and goals for productivity, economic development, livelihood opportunities and gender equality.

2.2 Interpreting and using CLEANED outputs

2.2.1 A representation and simplification of the real world

Any application of CLEANED is just a model, and as such it is just a simplification of reality. The initial parameterization of a CLEANED tool for a new study area, henceforth referred to as the 'base run', is therefore a simplified virtual landscape that tries to represent the reality on the ground as far as possible, i.e. by using the most accurate and realistic dataset possible for the user. But it is not possible (or necessary) to reproduce all the complexity of reality, and the base run remains a sort of "virtual landscape" with features that are inspired by the information obtained from literature, the reconnaissance tour, key informants and Workshop 1, which in turn (preferably) represent the features that are seen to be important and relevant by the stakeholders.

The CLEANED tool then computes the different environmental impacts of any scenario relative to this base run, i.e. the representation of reality developed for the CLEANED tool in that specific case study. This is because any bias or uncertainties in the initial parametrization (i.e. due to missing information or errors in representation) will then also be present in the scenarios. So, by computing the difference between the scenario and the base run, the bias is accounted for.

For other applications of CLEANED, to another context or to answer different questions, the parameterization would need to be adjusted to that context, and would contain a different set of important and relevant features extracted from literature, consultations and expert knowledge to represent a slightly different reality. Two different applications of CLEANED, i.e. different parameterisations, can then only be compared in terms of relative change from their respective base runs and not in terms of absolute level of impact, as these levels are rooted in a different 'reality'.

A useful way of producing comparable results is to record the rationales used to design the scenarios in each application of CLEANED, and the evaluation of the associated impacts. As the user explores the assumptions and the constraints in the context of that 'reality', they will identify patterns and relationships, storylines of possible change in production and associated impact. The storylines identified by the user can be used to link results from an application of CLEANED to other models or across different applications (i.e. different 'realities') of CLEANED.

2.2.2 Sensitivity and non-linearities

In its current version of code development, a CLEANED tool is a set of linear and non-linear equations. An initial module computes the meat and milk production of the scenario and the land used to produce the feed and fodder to support this meat and milk production. This land requirement module is computed first and then

each of the environmental impacts is computed independently, based on the first computations. As such there are no interactions between the different impacts, and therefore there are no self-reinforcing dynamics.

Yet, there are non-linear dynamics in the model, mainly driven by the different energy requirements of the different production categories, which are a function of the animal weight, the production per animal and the feed basket. In this way, the non-linearities that drive the model are defined by the assumptions of productivity gains that are possible by changing the feedbasket and breed. The vignettes produced for the CLEANED tool for Bama, Burkina Faso are one example of describing a set of plausible changes in production for Bama, which are underpinned by assumptions of productivity gains (see Section 3.4, and accompanying report, (Ensor et al., 2018)). This set of plausible vignettes was developed to be used by a non-expert audience in a workshop setting. It was critical to develop the vignettes carefully so that they would be credible to those who would use the tool, as the set of vignettes defines what choices a non-expert user can test and combine into scenarios for future change. If the vignettes are unrealistic for the context, the evaluation and negotiations of future scenarios in the livestock transformation game will be meaningless, or in the worst case misleading, in identifying potential ways to alter livestock production in the future.

3 CLEANED in Burkina Faso

The area of interest is Bama commune, 20km north-west of Bobo-Dioulasso in Houet Province, Hauts-Bassins region, Burkina Faso. Bobo-Dioulasso is the second largest city in Burkina Faso and considered by some to be the economic capital of Burkina Faso. The focus is on the cattle livestock population of Bama commune, which include transhumant animals and sedentary animals.

Assumptions in modelling CLEANED for Burkina Faso:

- CLEANED only calculates the impact of local resources consumed for the animals in the study area (see Section 3.1 Boundaries for more detail). This means that the impact of feed that is imported is not calculated, and the impact of animals while they are outside the study area is not calculated.
- Although CLEANED calculates impact on an annual basis, i.e. the impact of the animals in Bama over one year, there is a seasonality computation that accounts for the cropping and the transhumance seasonality. (see section 3.3 Seasonality for more detail):
 - the number of animals present in the study area over the year and consuming local resources varies over the year with transhumance movements, so that some animals leave the area and some animals join the area for part of the year; and
 - the feed basket changes with the cropping season, so that there is a feed basket for the wet season and a feed basket for the dry season.
- The feed baskets for all categories of livestock production are split to have wet and dry season feed baskets. Because of this, even the transhumant animals consume a dry and wet season feed basket during a few months a year.

3.1 Boundaries of the study area

The CLEANED tool accounts for the feed and fodder production for the animals that are in the study area. For the transhumant animals, this means that CLEANED only considers the local feed and fodder required for the animals while they are in the study area. The choice of boundary for the study area is therefore important, for two reasons. First, the CLEANED tool is sensitive to the boundaries, because several of its metrics are calculated based on the whole area within the study area boundaries, such as total potential biomass available for feed and fodder (to give an indication of when the local net primary production limit is reached and further demand would need to be satisfied by imports) and the volume of water used by livestock as a proportion of total annual rainfall falling over the study area. Second, the pastoralists present in the first workshop felt that our approach and activities could not capture their system of production, and therefore sought assurance that their pastoral routes and zones would be taken into account in the CLEANED model for Burkina Faso, else there would be little point in their attending the second workshop.

There are three categories of transhumant animals. A small portion of the transhumant animals go on a long transhumance, joining the cross-border transhumant animals travelling between Mali and Ghana and/ or Côte

d'Ivoire (around 10% of the cattle in Bama). The majority of the transhumant animals go on a small transhumance route to the hills in the southern part of Padema and the fringes of neighbouring communes (around 23% of the cattle in Bama). The final portion are the lactating cows that stay in Bama all year round, the pastoral dairy herd (around 3% of the cattle in Bama). To capture the majority of the small transhumance route the boundaries of the study area follow the administrative boundary of Bama commune and then extends to include the southern part of neighbouring Padema commune (Figure 1).

CLEANED considers the pastoral dairy herd and small transhumance herds as they are in the study area the whole year round³. The animals that go on the long transhumance are only accounted for in CLEANED for the time that they are in the study area, which in CLEANED is assumed to be from July to November (see section 3.3 Seasonality for more detail). CLEANED also automatically calculates for animals that consume the local resources as they walk through the area on the long transhumance from Mali to Ghana and Cote d'Ivoire. These animals are assumed to be in the area for 2 months consuming freely available grass (from the grazing area) and crop residues from the fields they are passing through.

The choice of boundaries was based on the first workshop results, consultation with local experts following the first workshop, as well as consultation of literature on the transhumance routes in the area (Gonin and Gautier, 2015; Gonin and Tallet, 2012; GRAF, 2014). Figure 2 shows the areas used by pastoralists in Padema commune, including the hills in the south that are used by the Bama small transhumance cattle (Gonin and Tallet, 2012), which guided the cutoff point of the study area boundary in Padema.

³ The impact of the small transhumant animals while on small transhumance is far more distributed than while they are grazing locally in Bama, and therefore arguably over-accounted for in CLEANED, however, it is assumed that this lighter impact is balanced by their impact while they are outside the study area which is not formally captured in CLEANED.

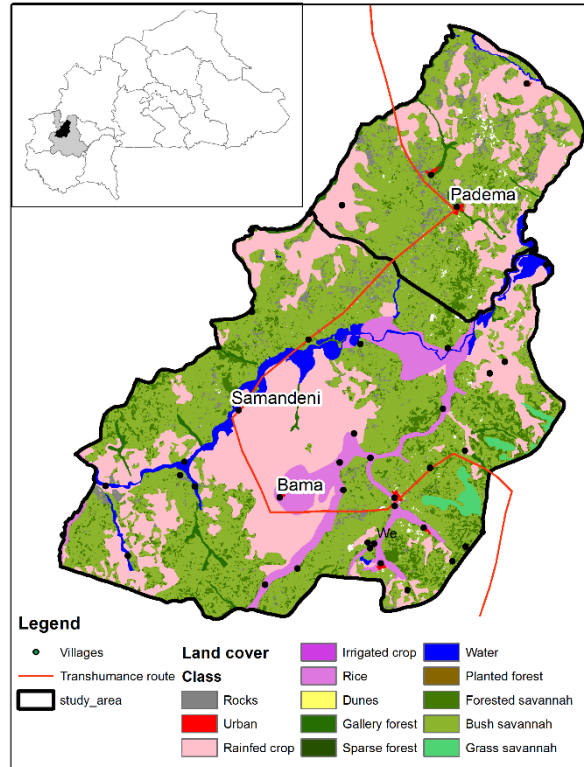


Figure 1: Study area boundaries for the cattle population of Bama Commune, Houet Province, including southern part of Padema Commune to the north

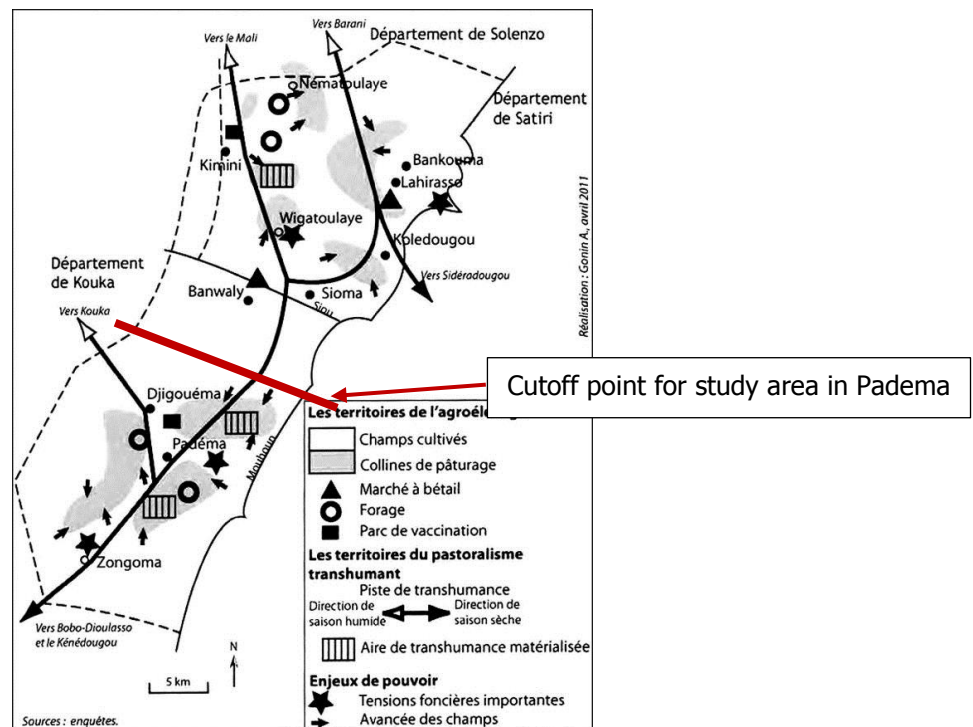


Figure 2: Pastoral land use in Padema commune (Source: Gonin and Tallet, 2012)

3.2 Livestock production in Bama

Based on the activities in the first workshop, the research team characterised the livestock production in Bama into five categories (Table 1). What is sought here is a representation that all stakeholders can recognise and work with, rather than describing the full complexity of reality. As such, these five categories describe common ways of keeping cattle, acknowledging that farmers may keep cattle in several categories at once, for example, having some on transhumance, a few kept at home for dairy, one or two draft animals, and perhaps some for fattening. The categories draw on two different ways of classifying livestock: i) in terms of practices, according to the product (milk, meat or draft power); and ii) in terms of production systems that describe the nutrition and herd management of the livestock. 'Extensive' refers to a feedbasket that is almost entirely free grazing; 'semi-intensive' refers to a feedbasket that contains concentrate feed with free grazing, but not a cross breed; and 'intensive' refers to improved breeds with mainly concentrate feed and very limited free grazing.

Table 1 : Production categories for Cattle production in Bama, Burkina Faso

		System		
		Extensive	Semi intensive	Intensive
Practice	Dairy	Pastoral dairy herd	Specialized dairy animals	
	Fattening	Pastoral transhumant herds (LT + ST)	Fattening animals	
	Rearing		Draft animals	

Note in particular the presence of both pastoralist and settled farming in the study area, and that the two are not mutually exclusive. For this reason, the categories focus on the animals as moving (pastoral/ transhumant) or not moving (draft, specialised dairy and specialised fattening) and do not specify who keeps them.

The pastoral cattle are kept extensively, sourcing feed predominantly from grazing by moving either long distances (**Long transhumant herds, LT**), or short distances (**Short transhumant herds, ST**)⁴. Cattle in this category are raised from birth until they need to be sold for funds (rearing). In some cases, cattle will be kept at home for fattening, fed well for a few months in order to sell for a better price. The animals from the overall herd that have given birth and therefore are giving milk are also kept home and become part of the **pastoral dairy herd**. The pastoral dairy herd is becoming more popular as a risk mitigation strategy, to allow part of the family, mainly women and children, to have a sedentary life and live from the sale of milk. As such, this pastoral system, that is extensive, includes all practices of rearing, fattening and dairy production. Then, there are the cattle that do not move - the **draft animals** and an emerging semi-intensive specialisation in dairy and meat production. The **specialised dairy** cattle are kept at home, sourcing feed from natural grass within a day's walk from home but supplemented by concentrates and planted fodder. They may also be improved breeds. Those specialising in **fattening** nowadays generally buy animals (often from the pastoral system), often weaker or undernourished, and feed them well for two to six months before selling them for a profit (also called 'finishing'). In future this category might include male animals from the improved dairy herd.

At the time of the workshops (2017), pastoral dairy and specialised dairy are quite similar in management but are likely to process along different intensification paths, mainly in terms of breeds and therefore should be kept different. Specialised dairy and fattening (and to some extent draft animals) have the possibility to be 'intensive' in the future (full stabulation, mainly fed on feed mixes, planted fodder and concentrates, and further improvement in the breeds). Pastoral dairy can (and in some cases is already starting to) become 'semi-intensive' at least, in order to increase milk production, but will never be 'intensive', because the pastoral dairy animals may still need to go on transhumance at some point. The pastoral/ transhumant animals are unlikely to become 'semi-intensive', as they need to be hardy in order to survive the transhumance.

⁴ The long transhumance herds (LT) migrate between Mali and Cote d'Ivoire and Ghana sometimes over many years, whereas the short transhumance herds (ST) move more locally, in this case only travelling within Bama, the southern portion of Padema and the fringes of neighbouring communes, over the course of the dry season.

3.2.1 Initial livestock numbers per production category

The present-day cattle livestock population is the starting point for the CLEANED tool for Bama, a 'base run' that is a simplified representation of the current situation. Scenarios describing alternative patterns of livestock production in Bama are compared against this base run, so that CLEANED provides an indication of change in environmental impact compared to the present day situation. As there are diverging statistics on the total number of animals in Bama and no statistics differentiating the total herd of Bama by the five production categories, a parametrization technique was developed to combine and triangulate data from participatory mapping exercises in Workshop 1, open access spatial data layers and freely accessible georeferenced household survey from several sources to calculate the number of cows as:

$$\widehat{n}_c = s_c \times \frac{pop}{hhs} \times \overline{n}_c$$

Where :

\widehat{n}_c is the number of animals for each of the five categories (c)

s_c is the share of household keeping livestock in a particular category c (from Workshop 1)

pop is the population in the area based on WorldPop population layer for Burkina Faso, at 100 m resolution, representing 2014 population estimates adjusted to match UN population estimates (<http://www.worldpop.org.uk/data/summary/?doi=10.5258/SOTON/WP00033>)

hhs is the household size in the province of Houet (from Demographic Health Survey, DHS, 2010, <https://dhsprogram.com/what-we-do/survey/survey-display-329.cfm>)

\overline{n}_c is the mode number⁵ of animals per household (from Workshop 1). For transhumant animals we used the number of troupeau and the average size per troupeau.

This result is triangulated with other available data, namely FAOstat (FAO, 2017), the gridded livestock of the world (Robinson et al., 2014), census data (Ministère des Ressources Animales, 2004), livestock ownership and household size data from DHS (Institut National de la Statistique et de la Demographie - INSD/Burkina Faso and ICF International, 2012)). The full details of this process are provided in Appendix 6.1.

It was also made clear in Workshop 1, that transhumant animals are counted in 'troupeaux', not in individual animals. See Workshop Report 1 for details. Based on discussions in Workshops 1 and 2 and consultation with local experts, a fully-fledged troupeau is defined by the pastoralists as a herd of about 70 cattle or more⁶. For the CLEANED parameterisation, troupeau size was defined to be 120 to account for variation in the actual size of a troupeau, acknowledging that 70 is a minimum (more details in Appendix 6.1). It is intended to err towards a high average, so as to avoid underestimating potential impact when running scenarios. The pastoral dairy are also counted in troupeaux, although these are smaller herds, typically 15-20 cattle. In CLEANED, pastoral dairy troupeaux have 20 animals.

The baseline or current state number of animals in each production category have been defined for Bama as set out in Table 2, along with the number of animals represented by each brick used in the Transformation Game.

⁵ The mode gives a truer representation of the most common herd size than an average or mean value would

⁶ The pastoralists in Workshop 2 reiterated this definition, highlighting that there can be confusion when talking about troupeaux, as the government agents consider a troupeau to have at least 15 animals

Table 2 : Number of animals in the baseline scenario in Bama, Burkina Faso

Category	Baseline CLEANED	Bricks	Single Brick value
Long transhumance herds ('troupeaux')	100 herds LT	10	10 troupeaux ^a
Short transhumance herds ('troupeaux')	238 herds ST	24	10 troupeaux ^a
Pastoral dairy herds ('troupeaux')	200 herds	20	10 troupeaux ^b
Specialized dairy animals	1'400	14	100 animals
Fattening animals	55'000	55	1000 animals
Draft animals	22'500	23	1000 animals
Total animals	123'460		

^a 120 animals per troupeaux

^b 20 animals per troupeaux

3.3 Seasonality for Burkina Faso

Two different seasonalities shape the calculation of feed and fodder demand in the study area, as shown in Table 3. These are a crop-related seasonality, which influences the feed basket, and a livestock transhumance-related seasonality that influences how many animals are in the area.

The livestock numbers in the area are (slightly) reduced by animals from Bama's population leaving the area for part of the year, and (slightly) increased when animals from outside of Bama pass through for a short time. CLEANED considers animal presence over the year as follows:

- The pastoral dairy herd and small transhumance herds⁷ are in the study area the whole year round (see section 3.1 Boundaries for more detail).
- The animals that join the long transhumance are only accounted for in CLEANED from July to November, the wet season, during which they graze locally in Bama.
- CLEANED also automatically calculates for animals that consume the local resources as they walk through the area on the long transhumance from Mali to Ghana and Cote d'Ivoire. These animals are assumed to be in the area for 2 months consuming freely available grass (from the grazing area) and crop residues from the fields they are passing through.

In terms of crops, there are two major seasons: a rainy season from May to September during which natural grass is plentiful but crop fields need to be protected, and a dry season during the rest of the year, when crop residues become the main feed source. In CLEANED, the feed baskets for all categories of livestock production are split on this seasonality, i.e. a feed basket for the wet and a feed basket for the dry season. Because of this, even the transhumant animals consume a dry and wet season feed basket during a few months a year (represented by ws_st1, ds_st1).

Table 3 : Seasonality in the CLEANED tool for Bama, Burkina Faso

	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
Transhumance seasonality	Transhumant animal out of the study area (st2)						Transhumant animals in the study area (st1)					
Crop seasonality	Dry season (ds)				Rainy season (ws)					Dry season (ds)		
CLEANED sub-season names	ds_st2				ws_st2		ws_st1			ds_st1		

⁷ The impact of the small transhumant animals while on small transhumance is far more distributed than while they are grazing locally in Bama, and therefore arguably over-accounted for in CLEANED, however, it is assumed that this lighter impact is balanced by their impact while they are outside the study area which is not formally captured in CLEANED.

The wet season feed basket, used for 5 months by each of the five production categories in varying ratios includes: natural grass and supplements (concentrates, agricultural by-products such as cotton-seed cake).

The dry season feed basket, used for 7 months by each of the five production categories in varying ratios includes: crop residues (maize stover and rice straw), dry grass, tree leaves and supplements.

3.4 Vignettes – storylines of plausible change

Vignettes are credible combinations of feed baskets with animal productivity for each animal category representing different livestock management options within each production category (Table 4). These vignettes are pre-set within the code, so that the non-expert can develop credible scenarios (that is, combinations of vignettes defining the production across the landscape). These vignettes were defined based on a literature review about livestock productivity and breeds in Burkina Faso. The initial numbers from the literature were reviewed by a feed and fodder expert who developed the full parameterization of these vignettes and ensured that the feedbasket entered into CLEANED is credible and based on nutrition available in Bama (see full details in Appendix 6.2).

Table 4 : Vignettes and their descriptions. A total of 13 vignettes comprise the current version of each production category (five vignettes) and one or two alternative futures for each category (eight vignettes).

	Code	Description
Trans-humant herds (A)	ABR: Baseline (current state)	Current way of keeping pastoral non-dairy animals relying mainly on grass and crop residues
	A1: somewhat improved	Pastoral animals get little supplements (oil seed cake and bran) during the dry season
Pastoral dairy herds (L)	LBR: Baseline (current state)	Current way of keeping pastoral dairy animals relying mainly on grass and crop residues
	L1: somewhat improved	Dairy pastoral animals get little supplements (oil seed cake and bran) during the dry season
	L2: much improved	Dairy pastoral animals get fed the optimum amount of supplements (oil seed cake and bran in both seasons)
Specialized dairy (improved breeds) (D)	DBR: Baseline (current state)	Current specialized dairy production with improved breed and little supplements (bran and oil seed cake)
	D1: somewhat improved	Specialized dairy production with improved breed and some supplements (bran and oil seed cake) and little use of planted fodder
	D2: much improved	Specialized dairy production with improved breed and optimum supplements (bran and oil seed cake) in combination of planted fodder (no crop residues)
Fattening animals (Fa)	FBR: Baseline (current state)	Current fattening with little use of supplements (bran and oil seed cake)
	F1: somewhat improved	Fattening with medium use of supplements (bran and oil seed cake) more relying on crop residues than grass
	F2: much improved	Fattening with important use of supplements (bran and oil seed cake) more relying on crop residues and planted fodder
Draft animals (Tr)	TBR: Baseline (current state)	Current draft animal keeping relying on grass and crop residue only
	T1: somewhat improved	Draft animal keeping with supplements (bran and oil seed cake) during the wet season

3.5 Adjusting the tool to include moving animals

In the ResLeSS project, the CLEANED tool for Bama provides the environmental perspective in Workshop 2. To do so, the CLEANED tool takes the numbers of animals in the area, computes their energy need and then calculates what feed and fodder will need to be produced in the selected area to fulfil these needs and finally computes the impact of that and how different it is to the present-day situation, the 'base run'.

However, to support the project objectives the tool has also been developed in such a way as to ensure that discussions prompted by the tool's output are relevant to the stakeholders and enable learning.

From Workshop 1, we discovered that the biggest tension in the area is between pastoralists and more sedentary farmers. Pastoralists fear losing their rights to continue an extensive livestock production that optimizes their risk management in a world that drives toward intensification and productivity gains, which is the only world that previous CLEANED tool applications were able to handle. After a negotiation with the pastoral community representatives, we had an agreement with the pastoralists that their interests would not be ignored within the whole process and that the CLEANED tool would make appropriate adjustments to its logic to account for the pastoral system. This agreement contained three conditions:

- 1. The model is able to take the pastoral production into account.
- 2. We will not talk of numbers of animals in the pastoral system.
- 3. Our model takes the pastoral routes and zones that are currently in negotiation into account.

As a result of the second condition, the CLEANED tool interface for Bama requires that the number of animals in the transhumant and pastoral dairy categories are entered as number of *troupeaux* and there is an assumption of how many animals are in a herd. That number was not discussed during Workshop 2.

The first and the third conditions were more difficult to fulfil, as it requires introducing the pastoral way of production, i.e. mobile livestock into a model that was developed for highland areas where animals do not move. This required to first understand what the pastoral system is. A literature review gave the missing puzzle pieces to the stories we could gather from the reconnaissance tour and the workshop 1. The insights we got were the following :

1. There are two types of pastoralists in the area, there are those pastoralists who come from Mali and cross Bama during 2 months a year on their way to Ghana or Cote d'Ivoire. Then there are pastoralists who are based in the study area, whose livelihood is mainly based on livestock, and who send part of their herd to join the transhumance to the South as the other pastoralists pass through Bama. This latter group historically came from the North and were given the right to sedentarize, but at the same time kept moving animals. Pastoralists who just pass through have not been explicitly modelled, but the indicative carrying capacity of the area⁸ has been reduced to account for these animals.
2. Pastoralists that have their 'home base' in the area where modelled explicitly. They have 4 types of animals, a dairy herd consisting of the lactating animals that remains around the home stead, animals that leave the home during the harvesting time to the nearby hills, also known as the small transhumance, and animals that join the small transhumance but continue on the long transhumance, i.e. are going to Ghana or Cote d'Ivoire. For these 3 categories it is impolite to ask about number of animals, one usually talk of herds or *troupeaux*. Finally, pastoralists also do fattening, but this activity is viewed as separate, and one can talk about the number of individual animals.
3. There are pastoral zones and routes that are currently being negotiated. These would be grazing areas with public access. Anyone would be able to come and graze in these areas and cropping would not be allowed. These area include the hills in Padema, where the official transhumance route passes through.

This led to various adjustments in CLEANED. Firstly, the delineation of the study area was chosen taking the pastoralist interests into account. From an environmental perspective, the model could have been developed correctly by using the Bama commune only, and considering the pastoral animals to be out of the study area

⁸ The maximum amount of biomass for feed and fodder that can be produced by the land in the study area over a year, using annual yield data from GAEZ (Global Agro-ecological Zones, agricultural suitability and potential yields data, <http://gaez.fao.org/Main.html#>)

for most of the time, including while on small transhumance, and therefore that portion of their impact would be effectively externalised. Using the expanded boundary to include the small transhumance route was an elegant way to mathematically include the pastoral production system, and keep most animals in the study area all year long, i.e. accounting for the majority of the pastoral production system's impact, as only a few animals go on the long transhumance.

The land cover change module developed for the CLEANED tool for Bama (see Appendix 6.4) was not used during the workshop in order to reduce the number of variables introduced for discussion. Yet this module was developed in such a way that stakeholders can test the implications of keeping the pastoral routes open, by protecting those areas from land use change. This module was used for the valuation of impacts shown in Appendix 6.3.1. These scenarios show that there is little impact for the sedentary farmers, yet if these transhumance routes are not protected there are plausible scenarios that show that the routes would be closed and would oblige pastoralist to quit their mobility.

The vignettes that were developed for CLEANED took into account interests from the pastoralist. Firstly, the more intensified vignettes in the transhumance and pastoral dairy categories do not offer the option of cross-breeds, as improved breeds are generally not strong enough to go on transhumance. As a result, the pastoral dairy vignette which represents the lactating cows from the transhumant herds, only allowed improvement through the feed basket and through selective breeding (not cross-breeds). Also, none of the feed baskets for animals in the pastoral system contain any planted fodder, as pastoralists are mobile and do not have the option to grow fodder. Once the pastoralists realised this, in Workshop 2, they gained trust in the tool. Changing breed and introducing planted fodder would imply a move to a different system, rather than a development of the pastoralist system.

The parametrization method developed to get the base run for the study area was developed in such a way that there was no compromise on the quality and accuracy of the environmental output of CLEANED, but making sure that the tool adequately represents the stakeholders managing the livestock in Bama so as to be useful to them.

4 Functioning of CLEANED tool for Bama

The CLEANED tool for Bama has a simple user interface in RShiny that allows the user to enter a new scenario to be tested, run the tool and view the results (Figure 3). A new scenario is designed by selecting a vignette for each of the five production categories and choosing how many animals or troupeaux to have in that category. If the category has disappeared in a particular scenario, select any vignette and set the number of animals to 0.

Full results of the stakeholder group scenarios are in Appendix 6.5, and for the mixed group scenarios (A and B) in Appendix 6.6.

Metrics used in the Workshop 2 to give a quick idea of impacts to evaluate in the discussions were:

- Productivity impacts: Meat produced (tons); Milk produced (tons); Cropland used (ha); Grazing land used (ha); Rice area used (ha)
- Environmental impacts: Total water use per animal (l/year); Water use per head; Total greenhouse gas emitted (kg CO₂-equivalents); Greenhouse gas emitted per head; Average nitrogen balance in soil.

For all impact results, which are presented as % change in impact from the base run, CLEANED also provides an automatic guide as to whether the change is low, medium or high, relative to the range of plausible change in impacts for the study area (based on plausible scenarios; Appendix 6.3). This assessment allows the users to gain a sense of the scale of change. The users can then make their own (subjective) evaluation of what this impact means to them, based on their knowledge of the context.

SAIRLA PROJECT : CLEANED INTERFACE ILRI

[Feed basket](#)
[Water pathway](#)
[Greenhouse gas pathway](#)
[Biodiversity pathway](#)
[Soil pathway](#)

Click here to update feed basket

PRODUCTION CATEGORIES :: DATA ALREADY LOADED

Enter your name here:

	PASTORAL TRANSHUMANT HERD	PASTORAL DAIRY HERD	DAIRY ANIMALS	FATTENING ANIMAL	DRAFT ANIMALS
LongT	50	78	50	N/A	N/A
Number of troupeaux(herd)	50	78	50	N/A	N/A
Number of animals per troupe	120	120	20	N/A	N/A
Number of Animals	**	**	**	2800	65000
ShortT					
Number of animals crossing area:					2300

Figure 3: User interface for the CLEANED tool for Bama, Burkina Faso

5 References

- Ensor, J., Pfeifer, C., Morris, J., Ran, Y., Ouedraogo, S., 2018. Exploring alternatives for livestock production in Bama, Burkina Faso: Playing the Transformation Game. Report of ResLeSS Workshop 2 (SAIRLA Project report). Stockholm Environment Institute, York.
- Fraval, S., 2014. Review of live-cycle assessments for livestock, fisheries and aquaculture: perspectives for application to environmental impact assessment in developing countries. (Consultancy report to ILRI). International Livestock Research Institute, ILRI, Nairobi, Kenya.
- GAEZ, 2012. Crop-specific actual evapotranspiration (mm) (Latest update: 05 Mar 2014) (GeoLayer). Food and Agriculture Organization of the United Nations, Rome.
- Gonin, A., Gautier, D., 2015. Shift in herders' territorialities from regional to local scale: the political ecology of pastoral herding in western Burkina Faso. *Pastoralism* 5, 7. <https://doi.org/10.1186/s13570-015-0023-z>
- Gonin, A., Tallet, B., 2012. Changements spatiaux et pratiques pastorales: les nouvelles voies de la transhumance dans l'Ouest du Burkina Faso. *Cah. Agric.* 21, 448–454 (1). <https://doi.org/10.1684/agr.2012.0595>
- GRAF, 2014. Pastoralisme : Pistes salvatrices (GRAF Infos No. 35). GRAF.
- Hamadou, S., Tou, Z., Toé, P., 2008. Le lait, produit de diversification en zone périurbaine à Bobo-Dioulasso (Burkina Faso). *Cah. Agric.* 17, 473–478.
- Institut National de la Statistique et de la Demographie - INSD/Burkina Faso, ICF International, 2012. Burkina Faso Enquete Demographique et de Sante et Indicateurs Multiples (EDSBF-MICS IV) 2010. Institut National de la Statistique et de la Demographie - INSD/Burkina Faso and ICF International, Calverton, Maryland, USA.
- IPCC, 2006. Chapter 10: Emissions from livestock and manure management, in: 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change.
- IUCN, 2017. The IUCN Red List of Threatened Species. Version 2017-3.
- Ministère des Ressources Animales, 2004. Les statistiques du secteur de l'élevage au Burkina Faso. Ministère des Ressources Animales, Ougadougou, Burkina Faso.
- National Research Council, 1996. Nutrient Requirements of Beef Cattle: Seventh Revised Edition: Update 2000. <https://doi.org/10.17226/9791>
- Notenbaert, A., Lannerstad, M., Herrero, M., Fraval, S., Ran, Y., Paul, B.K., Mugatha, S., Barron, J., Morris, J., 2014. A framework for environmental ex-ante impact assessment of livestock value chains. Presented at the 6th All Africa Conference of Animal Agriculture, International Center for Tropical Agriculture (CIAT), Nairobi, Kenya.
- Ran, Y., Lannerstad, M., Barron, J., Fraval, S., Paul, B.K., Notenbaert, A., Mugatha, S., Herrero, M., 2015. A review of environmental impact assessment frameworks for livestock production systems (SEI Project Report No. 2015-03). Stockholm Environment Institute, Stockholm.
- Robinson, T.P., Wint, G.R.W., Conchedda, G., Boeckel, T.P.V., Ercoli, V., Palamara, E., Cinardi, G., D'Aiotti, L., Hay, S.I., Gilbert, M., 2014. Mapping the Global Distribution of Livestock. *PLOS ONE* 9, e96084. <https://doi.org/10.1371/journal.pone.0096084>
- Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., de Haan, C., 2006. Livestock's long shadow: environmental issues and options. FAO, Rome.

6 Appendix

6.1 Initial livestock numbers in CLEANED

Getting initial livestock numbers for the 5 production categories is not straight forward. No statistics report the livestock number in those categories, therefore a quantification method was developed to come up with this numbers.

Initial livestock numbers were calculated using the following rule:

$$\widehat{n}_c = s_c \times \frac{pop}{hhs} \times \bar{n}_c$$

Where :

\widehat{n}_c is the number of animal for category c, c[Ap, L, D, F, T]

s_c is the share of household keeping livestock in category c

pop is the population is the area based on worldpop layer 100 m from Burkina Faso representing 2014 population estimates adjusted to match UN population (<http://www.worldpop.org.uk/data/summary/?doi=10.5258/SOTON/WP00033>)

hhs is the household size in the province of Houet (from Demographic Health Survey, DHS, 2010, <https://dhsprogram.com/what-we-do/survey/survey-display-329.cfm>)

\bar{n}_c is the mode number of animals, taken from the participatory mapping exercise in workshop 1. For transhumant animals we used the number of troupeau and the average size per troupeau.

Several approaches have been tested and compared (Table 5).

Method 1 (M1)

Applies the formula above, where:

s_c is taken from the participatory mapping workshop.

hhs is the average households size of households in the Houet province taken from Demographic Health Survey from 2010

\bar{n}_c is the mode number of animals per category taken from the participatory mapping workshop

The share of population owning a draft animal was not asked during the workshop, so the average land ownership extracted from DHS was multiplied by two, assuming two draft animals per cropping household.

Also the share for specialized dairy could not be derived from the workshop. This share was therefore based on a CIRAD study (Hamadou et al., 2008) that suggested that 0.614 % of the households have improved dairy cows.

Method 2 (M2)

This methods is the same than M1, but $\frac{pop}{hhs}$ is replaced the household number from Bama commune and half of the households in Padema commune (as the study area is only half of the commune) from the census 2006

data. Note that the census data of livestock head has not been released at commune level but only at province level.

Method 3 (M3)

This method considers all cattle together and computes

$$\widehat{n}_c = \frac{pop}{hhs} \times \bar{n}_c$$

Where :

hhs is the average households size of households in the Houet province taken from Demographic Health Survey from 2010

\bar{n}_c is the average number of cattle owned by a household based on DHS

Method 4 (M4)

This method is the same than M3, but $\frac{pop}{hhs}$ is replaced the household number from Bama commune and half of the households in Padema commune from the census 2006 data

Method 5 (M5)

This method consists of extracting the cattle distribution map (Robinson et al 2014), corresponding de facto to the FAO statistics in 2010. Though this data is official from the country, it is actually just reflecting a 2% increase per year since the latest census data and will only be adjusted with the next census data (personal communication).

Table 5 : Comparison of livestock population numbers calculated using different methods

Category	Method 1	Method 2	Method 3	Method 4	Method 5	Base run CLEANED
Long transhumance	9'213	9'284	-	-	-	12'000
Short transhumance	23'692	23'871	-	-	-	28'500
Pastoral dairy	3'948	3978	-	-	-	4'000
Specialized dairy	950	1140	-	-	-	1'400
Fattening	49'437	59'439	-	-	-	55'000
Draft	18'634	22'404	-	-	-	22'500
Total	105875	120117	97256	116933	132631	123'400

For the original parameterization, the objective was to be on the upperside of animal numbers in the area, so that carrying capacity would be reached quicker. To reach this, method 2 was used, where we have increased also the average herd size to 120 animals per herd (the original only counted 100) which explains the increase the number of animals in the pastoral system. Fattening should have been at 60 000, however it was too late when we realized that we rounded down rather than up.

6.2 The full vignette parametrization in CLEANED

Vignettes correspond to a combination of input variables in the CLEANED tool for Bama that are consistent, i.e. the productivity of an animal that is possible given the feed basket. The following table shows the parametrization of the vignettes in the CLEANED tool for Bama that were used during the Workshop 2 Transformation Game.

The final vignettes were cross-checked by a local feed and fodder expert.

n

description name	agro-pastoral category base ru ameliore				agro-pastoral milk category base run ameliore perf.				dairy category base run semi pref. perf				fattening category base run semi pref. perf				draft animals category base run ameliore		
	Avar	ABR	A1	A2	Lvar	LBR	L1	L2	Mvar	MBR	M1	M2	Fvar	FBR	F1	F2	Tvar	TBR	T1
Alive weight (kg)	lwes	200	210		lwes	220	230	250	lwis	250	250	300	lwsis	250	270	500	lwda	200	210
Milk production (kg/cow/year)		0			myles	300	600	1200	myis	1000	3000	6000	mysis	0	0	0	myda	0	0
Dressing percentage	des	0.38	0.4			0				0			dsis	0.48	0.5	0.6	dsda	0	0
Feed basket wet season																			
<i>Natural grass</i>	efng1	100	100		lefng1	100	80	70	ifng1	80	50	0	sfng1	80	60	30	dafng1	100	95
<i>Cereal crop residue</i>	efrc1	0	0		lefrc1	0	0	0	ifrc1	0	0	0	sfr1	0	0	0	dafrc1	0	0
<i>Rice crop residue</i>	efrr1	0	0		lefrr1	0	0	0	ifrr1	0	0	0	sfr1	0	0	0	dafrr1	0	0
<i>Legume crop residue</i>	efrl1	0	0		lefrl1	0	10	10	ifrl1	0	0	10	sfr1	0	10	10	dafrl1	0	0
<i>Planted fodder</i>	efpf1	0	0		lefpf1	0	0	10	ifpf1	0	20	40	sfpf1	0	0	10	dafpf1	0	0
<i>Concentrate – bran</i>	efcon1	0	0		lefcon1	0	0	0	ifcon1	10	15	20	sfcon1	10	15	20	dafcon1	0	2.5
<i>Concentrate – oil seed cake</i>	efconos1	0	0		lefconos1	0	10	10	ifconos1	10	15	30	sfconos1	10	15	30	dafconos1	0	2.5
Feed basket dry season																			
<i>Natural grass</i>	efng2	50	30		lefng2	50	20	5	ifng2	35	20	0	sfng2	30	20	0	dafng2	30	10
<i>Cereal crop residue</i>	efrc2	30	40		lefrc2	30	45	50	ifrc2	35	30	0	sfr2	45	45	40	dafrc2	50	45
<i>Rice crop residue</i>	efrr2	20	20		lefrr2	20	25	10	ifrr2	10	10	0	sfr2	15	20	20	dafrr2	15	30
<i>Legume crop residue</i>	efrl2	0	0		lefrl2	0	0	15	ifrl2	10	10	0	sfr2	5	0	20	dafrl2	5	5
<i>Planted fodder</i>	efpf2	0	0		lefpf2	0	0	0	ifpf2	0	10	40	sfpf2	0	5	0	dafpf2	0	0
<i>Concentrate – bran</i>	efcon2	0	5		lefcon2	0	5	10	ifcon2	5	10	30	sfcon2	2.5	5	10	dafcon2	0	5
<i>Concentrate – oil seed cake</i>	efconos2	0	5		lefconos2	0	5	10	ifconos2	5	10	30	sfconos2	2.5	5	10	dafconos2	0	5
Manure management																			
% in lagoon	es_lagoon_perc	0	0		les_lagoon_perc	0	0	0	is_lagoon_perc	0	0	0	sis_lagoon_perc	0	0	0	da_lagoon_perc	0	0
% as liquid slurry	es_liquidslurry_perc	0	0		les_liquidslurry_perc	0	0	0	is_liquidslurry_perc	0	0	0	sis_liquidslurry_perc	0	0	0	da_liquidslurry_perc	0	0
% as solid storage	es_solidstorage_perc	0	0		les_solidstorage_perc	20	20	20	is_solidstorage_perc	100	100	100	sis_solidstorage_perc	100	100	100	da_solidstorage_perc	100	100
% as drylot	es_drylot_perc	0	0		les_drylot_perc	0	0	0	is_drylot_perc	0	0	0	sis_drylot_perc	0	0	0	da_drylot_perc	0	0
% left on pasture	es_pasture_perc	100	100		les_pasture_perc	80	80	80	is_pasture_perc	0	0	0	sis_pasture_perc	0	0	0	da_pasture_perc	0	0
% daily spread storage	es_dailyspread_perc	0	0		les_dailyspread_perc	0	0	0	is_dailyspread_perc	0	0	0	sis_dailyspread_perc	0	0	0	da_dailyspread_perc	0	0
% in digester	es_digester_perc	0	0		les_digester_perc	0	0	0	is_digester_perc	0	0	0	sis_digester_perc	0	0	0	da_digester_perc	0	0
% used as fuel	es_fuel_perc	0	0		les_fuel_perc	0	0	0	is_fuel_perc	0	0	0	sis_fuel_perc	0	0	0	da_fuel_perc	0	0
% other																			

6.3 Valuation of environmental impact in CLEANED

In order to generate an automatic score to indicate the relative scale of impact of the different scenarios, i.e. to define whether the change is low, medium or high with respect to plausible change in the study area, explorative scenarios have been developed. The different scenarios define the range of plausible change. This range was cut into 3 equal intervals defining the low, medium and high.

6.3.1 The developed exploratory scenarios

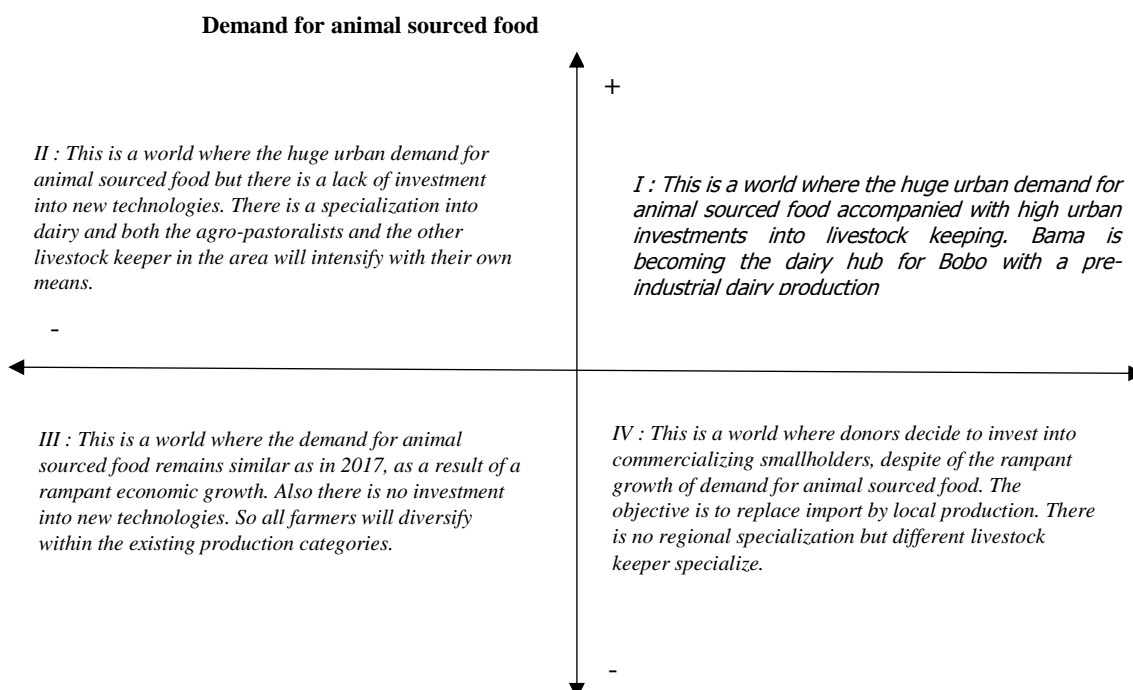
The exploratory scenario describes events and trends as they could evolve based on alternative assumptions on how these events and trends may influence the future. They provide several plausible futures that include external factors (the ones we do not have any influence on) and internal factors (elements it is possible to affect). The setup of such scenarios is usually based on two major uncertainties that cannot be influenced by the stakeholders but that will shape the outcomes.

For Bama, we worked with two uncertainties

1. The demand of animal sourced food, which generally correlates with economic development. The emerging middle class demands from more animal sourced food. Yet, Burkina Faso remain one of the least developed countries, and the civil unrest of the last years have always correlated with a reduction in GDP. Clearly the emergence of that middle class will depend on the economic growth that will only come with political stability.
2. Level of investment into the agricultural sector and with a particular focus in livestock production. In developing countries, there are various options of investment, agriculture is one among many and competing with the energy sector, real-estate, industrial production. The technologies available in the agricultural sectors will heavily depend on how much funds are made available for the sector.

Working with these two uncertainties leads to the four following scenarios:

1. Scenario I : The dairy hub Bama
2. Scenario II : The smallholder revolution works
3. Scenario III : Mission " surviving "
4. Scenario IV : The donor driven intensification



Scenario I : the dairy hub Bama

This is a world where the huge urban demand for animal sourced food accompanied with high urban investments into livestock keeping. Bama is becoming the dairy hub for Bobo with a pre-industrial dairy production, with milking machines. This specialization take place thanks to new technologies. Improved efficient breeds are brought in, accompanied with a good veterinary and breeding services. Also fodder production is improved, thanks to better seeds sorts and more fertilizer use. Also because of the specialization, there is a move away from crops to planted fodder. Thanks to these improvement is no encroachment onto the savannah for new cropland. Draft animals will almost disappear as tractors are taking over.

The overall growth of the whole industry offers many new opportunities to young people who now find jobs on the intensive farms and the processing plants that provide the dairy products demanded by the urban population of Bobo-Dioulassou. Because of these new opportunities, young people from agro-pastoral families, tend to settle and take jobs. Nonetheless, agro-pastoral families will keep their lifestyle as a sort of insurance, but the amount of animals will reduce because there is a lack of young people willing to open the transhumance route. This implies that each family that had troupeaux in 2017 will still have a maximum of one troupeau with about 75 animals.

CLEANED pre-set scenario I

Category	Chosen vignette	Livestock number
Agro-pastoralist transhumant	A1	Troupeau : - 20% with 100 animals
Agro-pastoralist dairy	L1	Troupeau : 0% with 25 animals
Dairy	D2	100 farms with 50 animals
Fattening	F1	0 %
Draft	TBR	-90%
Crop	C1	
Land use	LUC0	

Scenario II : the smallholder revolution works

This is a world where the huge urban demand for animal sourced food but there is a lack of investment into new technologies. There is a light specialization into dairy and both the agro-pastoralists and the other livestock keepers in the area will intensify with their own means.

Agro-pastoral communities will try to increase their amount of lactating cows, increase the animals for fattening and keep the other troupeaux a bit smaller. There is an emergence of commercial dairy and fattening farms. They make use of improved breeds, but not the highest performing ones, as there is not sufficient feed and fodder in the area, that kept cropping as in 2017, i.e. a strong orientation for staple crops, and no investment into planted fodder. Therefore, there is a massive increase of cropland encroached on the savannah.

Because in this scenario there is large economic growth, we will also assume that policies that allow the co-existence of the different production systems, and therefore the pastoral routes and zones could be enforced.

CLEANED pre-set scenario II

Category	Chosen preset	Livestock number
Agro-pastoralist transhumant	A1	Troupeau : 0% with 100 animals
Agro-pastoralist dairy	L1	Troupeau : 20% with 25 animals
Dairy	D1	+ 100%
Fattening	F1	+ 0%
Draft	TBR	0 %
Crop	CBR	
Land use	LUC4	

Scenario III : mission "surviving"

This is a world where the demand for animal sourced food remains similar as in 2017, as a result of a rampant economic growth. Also, there is no investment into new technologies. There is little incentive to improve the production. Yet, all livestock keepers' major objective will be to insure their livelihood. Because there are not many other opportunities, young people stay in rural area. As a result, there are more households keeping similar amounts of animals in similar way to today. However, all livestock keepers start diversifying the keeping strategy, so pastoral household will keep some improved dairy cow and fattening animals, whereas other livestock keepers will start having animals that move, in order to cope with the risk in this business resulting from climate change. Also, crops will be produced in a similar way but because of the population pressure there is an increase of cropland of 20%. Also, because of the stagnant growth, the pastoral routes and zones could not be enforced.

CLEANED pre-set scenario III

Category	Chosen vignette	Livestock number
Agro-pastoralist transhumant	ABR	+23%
Agro-pastoralist dairy	LBR	+23%
Dairy	DBR	+23%
Fattening	FBR	+23%
Draft	TBR	+23%
Crop	CBR	
Land use	LUC2	

+23% is the expected growth of rural population in Burkina Faso by World Bank.

Scenario IV : the donor driven intensification

This is a world where donors decide to invest into commercializing smallholders, despite of the rampant growth of demand for animal sourced food. The objective is to replace import by local production. There is no regional specialization but different livestock keepers specialize and improve productivity in each production category. The same assumption on population growth than in scenario III. Because of the high population pressure, there will be a 20% increase in cropland. But donors will force the implementation of the agreement around pastoral zones and route.

CLEANED pre-set scenario III

Category	Chosen preset	Livestock number
Agro-pastoralist transhumant	A1	+23%
Agro-pastoralist dairy	L1	+23%
Dairy	M1	+23%
Fattening	F1	+23%
Draft	T1	+23%
Crop	C1	
Land use	LUC3	

+23% is the expected growth of rural population in Burkina Faso by World Bank.

6.3.2 Assigning the score to changes

The environmental indicators are computed for each scenario. The difference to the base run was computed in absolute values. The maximum of this absolute value is the credible range for the scenarios. This range value divided by three is the threshold value that has been used, as shown in Table 6 below, where X is the absolute value of the difference between a scenario and the base run.

Table 6: Assigning an automatic score to changes in environmental impact

Condition	Score
$X < \text{threshold}$	Low
$\text{Threshold} < X < 2 * \text{threshold}$	Medium
$X > 2 * \text{threshold}$	High

This rule has been applied to each environmental indicators. The threshold has been computed based on these computations:

productivity	output from the scenairo					difference				difference in absolute value					treshold
	base run	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	max	
meat	9683	10339	9683	11885	11885	6.8	0.0	22.7	22.7	6.8	0.0	22.7	22.7	23	7.7
milk	3800	7400	6400	4674	4674	94.7	68.4	23.0	23.0	94.7	68.4	23.0	23.0	95	31.7
croparea	556	556	833	833	667	0.0	49.8	49.8	20.0	0.0	49.8	49.8	20.0	50	16.7
grazarea	830	830	833	552	719	0.0	0.4	-33.5	-13.4	0.0	0.4	33.5	13.4	34	11.3
ricearea	104	104	104	104	104	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
ar_rc	3	3	3	4	4	-9.1	3.0	24.2	24.2	9.1	3.0	24.2	24.2	25	8.3
ar_g	449	415	469	551	551	-7.6	4.4	22.7	22.7	7.6	4.4	22.7	22.7	23	7.7
ar_rr	0	0	0	0	0	0.0	50.0	50.0	50.0	0.0	50.0	50.0	50.0	50	16.7
import_c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
import_g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
import_rr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
numcow	117460	108250	120860	1444172	1444172	-7.8	2.9	1129.5	1129.5	7.8	2.9	1129.5	1129.5	1130	376.7
numcow_tt	12000	14400	12000	14760	14760	20.0	0.0	23.0	23.0	20.0	0.0	23.0	23.0	23	7.7
numcow_tpt	28560	34800	12000	34800	34800	21.8	-58.0	21.8	21.8	21.8	58.0	21.8	21.8	58	19.3
numcow_tl	4000	4000	6000	4920	4920	0.0	50.0	23.0	23.0	0.0	50.0	23.0	23.0	50	16.7
numcow_d	1400	5000	2800	1722	1722	257.1	100.0	23.0	23.0	257.1	100.0	23.0	23.0	258	86.0
numcow_f	55000	55000	55000	67650	67650	0.0	0.0	23.0	23.0	0.0	0.0	23.0	23.0	23	7.7
numcow_da	22500	2250	22500	27700	27700	-90.0	0.0	23.1	23.1	90.0	0.0	23.1	23.1	90	30.0
water										0.0	0.0	0.0	0.0	0	0.0
wr_sum	138638099	127492339	146930835	130374908	98961822	-8.0	6.0	-6.0	-28.6	8.0	6.0	6.0	28.6	29	9.7
wdiff	1715601	1726747	1707308	1723864	1755277	0.6	-0.5	0.5	2.3	0.6	0.5	0.5	2.3	3	1.0
wu_animal	1180	1178	1216	904	686	-0.2	3.1	-23.4	-41.9	0.2	3.1	23.4	41.9	42	14.0
wu_milk	36484	17229	22958	27894	21173	-52.8	-37.1	-23.5	-42.0	52.8	37.1	23.5	42.0	53	17.7
wu_meat	14318	12331	15175	10970	8327	-13.9	6.0	-23.4	-41.8	13.9	6.0	23.4	41.8	42	14.0
wui_avg	0	0	0	0	0	-8.0	5.3	-6.7	-29.3	8.0	5.3	6.7	29.3	30	10.0
green house gaz										0.0	0.0	0.0	0.0	0	0.0
COe_l	231102447	190129690	246554707	296079143	288747780	-17.7	6.7	28.1	24.9	17.7	6.7	28.1	24.9	29	9.7
co2e_manure_l	86378279	60272253	96377351	118153793	110966149	-30.2	11.6	36.8	28.5	30.2	11.6	36.8	28.5	37	12.3
rum_co2e_year	144807210	129940479	150060304	177767624	177767624	-10.3	3.6	22.8	22.8	10.3	3.6	22.8	22.8	23	7.7
co2cow	1967	1756	2040	2054	2003	-10.7	3.7	4.4	1.8	10.7	3.7	4.4	1.8	11	3.7
co2milk	60816	25693	38524	63346	61777	-57.8	-36.7	4.2	1.6	57.8	36.7	4.2	1.6	58	19.3
co2meat	23868	18389	25464	24913	24296	-23.0	6.7	4.4	1.8	23.0	6.7	4.4	1.8	23	7.7
bio										0.0	0.0	0.0	0.0	0	0.0
bio_index_avg	0.15	0.15	0.12	0.12	0.14	0.0	-20.0	-20.0	-6.7	0.0	20.0	20.0	6.7	20	6.7
esp_sc_max	0	0	3	3	3										1.0
soil										0.0	0.0	0.0	0.0	0	0.0
SB_l	-12144199	-11607154	-10518943	-11406001	-12781717	-4.4	-13.4	-6.1	5.2	4.4	13.4	6.1	5.2	14	4.7
Ni_l	73821	57458	81642	98199		-22.2	10.6	33.0	-100.0	22.2	10.6	33.0	100.0	100	33.3
Ni_cow	1	1	1	0.68	0.65	-15.4	7.6	8.4	3.5	15.4	7.6	8.4	3.5	16	5.3

6.4 Land cover and transhumance zones in CLEANED

The CLEANED tool for Bama uses the Sahara and Sahel Observatory (OSS) 30 m resolution land cover map (<http://www.oss-online.org/rep-sahel>). When the land cover was crosschecked with photographs taken in the study area, the OSS map performed better than the MODIS land cover map (<http://glcf.umd.edu/data/lc/>).

The land cover change module for Burkina Faso, converts all types of savannah into cropland selecting random cells. Indeed, cropping in savanna is often shaped by high rotation, leaving areas used for cropping fallow in the subsequent years. As this phenomenon increases, more patches of cropped area will appear in the savanna, but changing location from year to year.

The land cover change module also protects the reserved pastoral zones and routes, which were identified based on the Bama land use plan, the paper by Gonin (Gonin & Tallet, 2012) and the GRAF transhumance routes (GRAF, 2014).

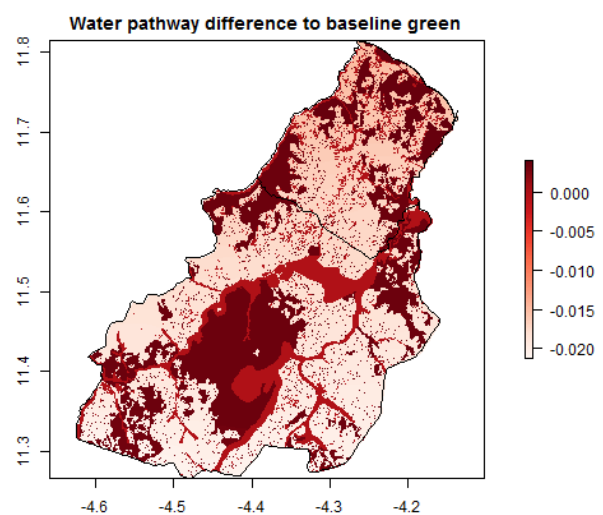
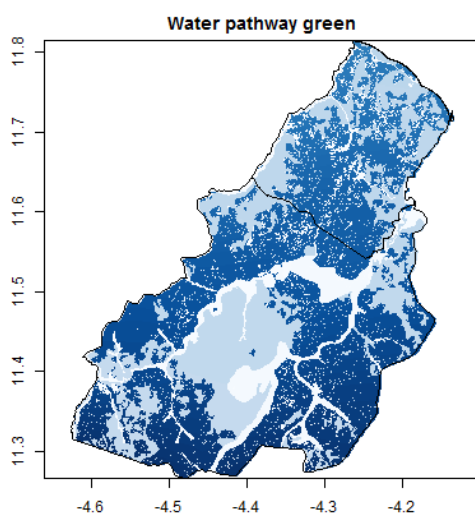
6.5 CLEANED output for the homogenous stakeholder group scenarios

Detailed CLEANED results for the 4 scenarios from Day 1 – which the groups did not see during the workshop.

6.5.1 Other farmers (Green group) *Productivity*

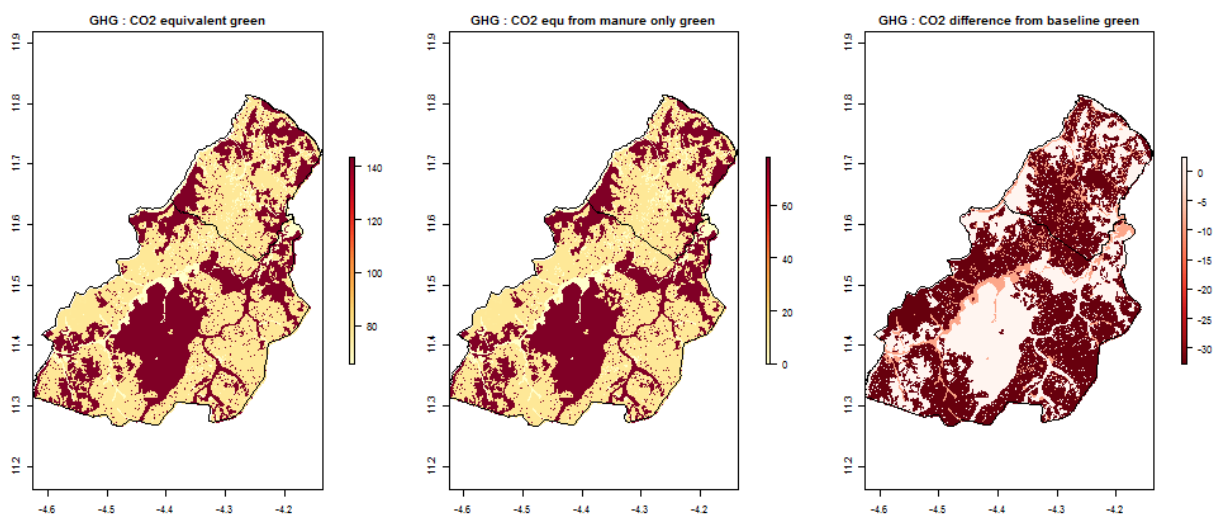
	base	diff	percent	evaluation
<i>meat produced</i>	8967.36	-715.2	-0.1	low
<i>milk produced</i>	3400.00	-400.0	-0.1	low
<i>total area available for crop</i>	556.00	0.0	0.0	low
<i>total area available for pasture</i>	830.00	0.0	0.0	low
<i>total available area for rice</i>	104.00	0.0	0.0	low
<i>crop area used</i>	2.90	-0.4	-0.1	low
<i>pasture area used</i>	381.10	-67.8	-0.2	low
<i>rice area used</i>	0.20	0.0	0.0	low
<i>import crop</i>	0.00	0.0	0.0	low
<i>import pasture</i>	0.00	0.0	0.0	low
<i>import rice</i>	0.00	0.0	0.0	low
<i>total numbers of cows</i>	104160.00	-13300.0	-0.1	low
<i>long transhumance cows</i>	6000.00	-6000.0	-0.5	low
<i>short transhumance cows</i>	9360.00	-19200.0	-0.7	low
<i>pastoral dairy cows</i>	1000.00	-3000.0	-0.8	low
<i>specialized dairy cows</i>	2800.00	1400.0	1.0	low
<i>fattening cows</i>	65000.00	10000.0	0.2	low
<i>draft animals</i>	23000.00	500.0	0.0	low

Water impact



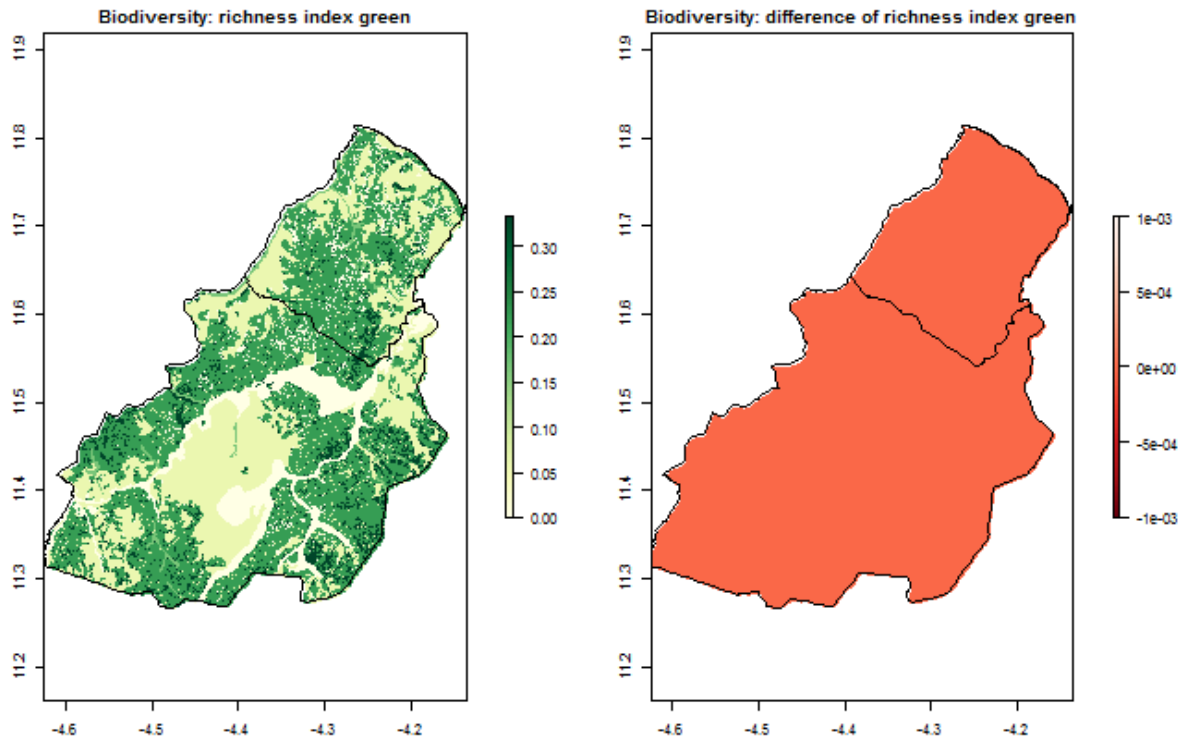
	result	difference	percent	evaluation
<i>total water consumption</i>	1.223402e+08	-16297893.000	-11.8	low
<i>difference between water consumption and rainfall</i>	1.731899e+06	16298.000	0.9	low
<i>water consumption per cow</i>	1.175000e+03	-5.000	-0.4	low
<i>water consumption per ton of milk</i>	3.598200e+04	-502.000	-1.4	low
<i>water consumption per ton of meat</i>	1.364300e+04	-675.000	-4.7	low
<i>average water consumption intensity</i>	6.600000e-02	-0.009	-12.0	low

Greenhouse gas emissions



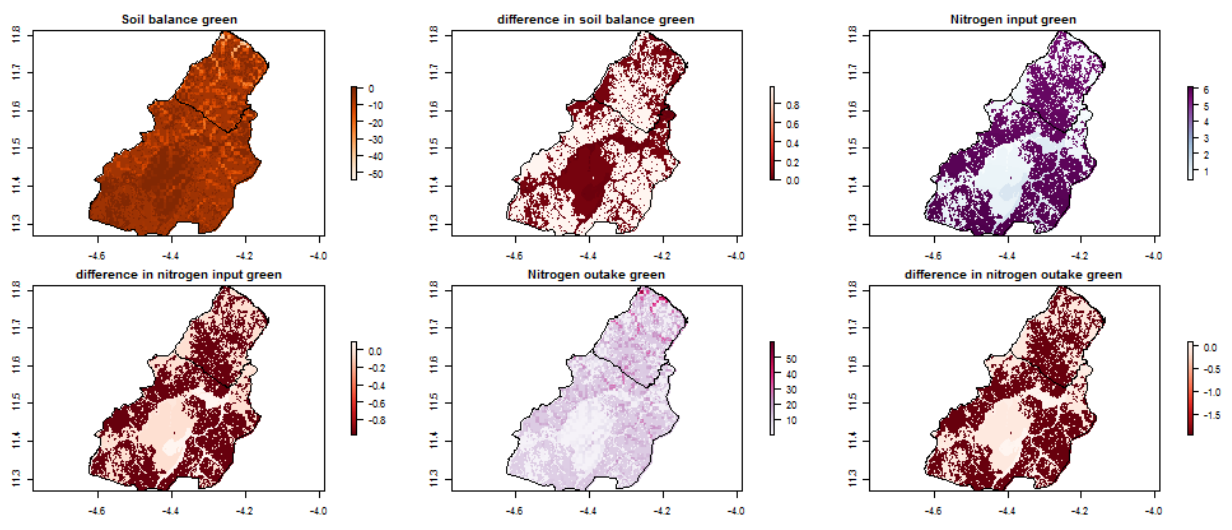
	result	difference	percent	evaluation
<i>CO2 emmissions</i>	196906581	-34195866	-14.8	low
<i>CO2 from manure</i>	69202612	-17175667	-19.9	low
<i>CO2 from interic fermetation</i>	127787011	-17020199	-11.8	low
<i>CO2 per cow</i>	1890	-77	-3.9	low
<i>CO2 per tonnes of milk</i>	57914	-2902	-4.8	low
<i>CO2 per tonnes of meat</i>	21958	-1910	-8.0	low

Biodiversity



	result	difffence	percent	evaluation
avg richness index	0.15	0	0	low
nbr of species loosing critical habitat	NA	NA	NA	NA

Soil health



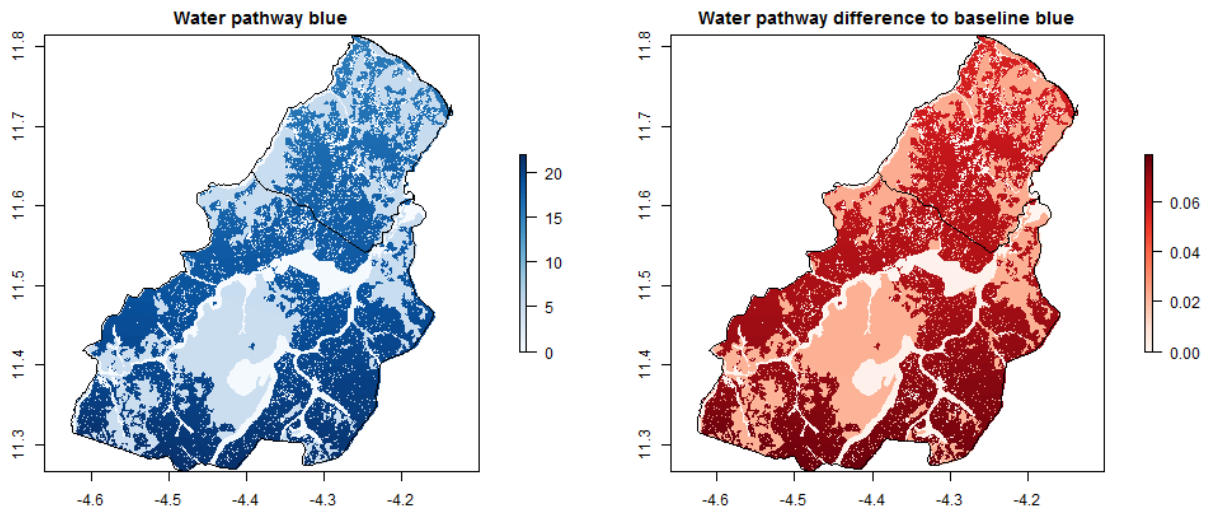
	result	difference	percent	evaluation
<i>nitrogen balance</i>	-11094815.000	1049384.000	-8.6	low
<i>total nitrogen added</i>	85878.000	12057.000	16.3	low
<i>nitrogen added per cow</i>	0.824	0.196	31.2	high

6.5.2 Pastoralists (Blue group)

Productivity

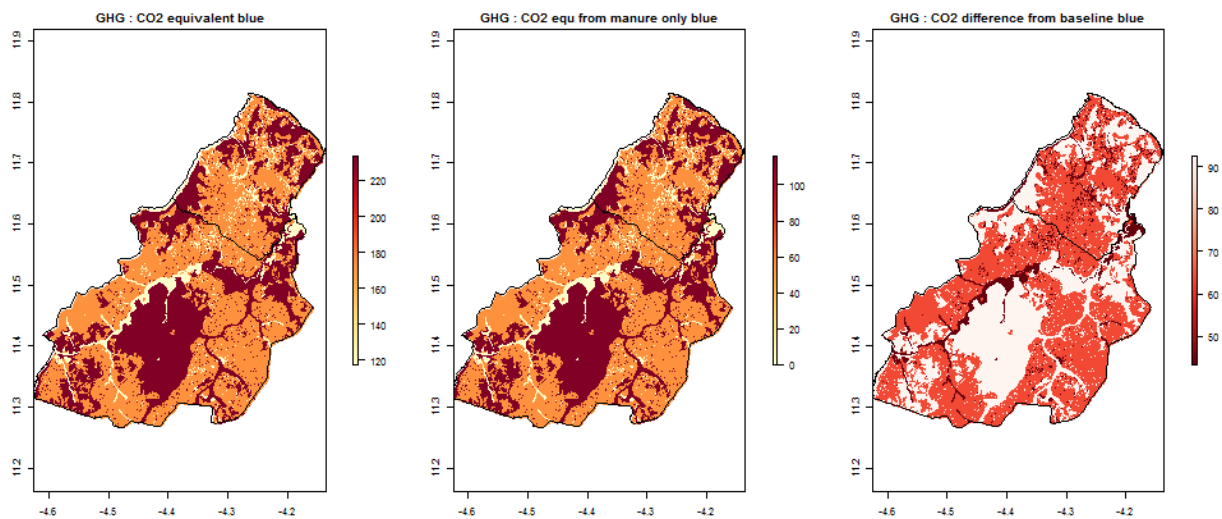
	base	diff	percent	evaluation
<i>meat produced</i>	17760.0	8077.44	0.8	low
<i>milk produced</i>	6000.0	2200.00	0.6	low
<i>total area available for crop</i>	556.0	0.00	0.0	low
<i>total area available for pasture</i>	830.0	0.00	0.0	low
<i>total available area for rice</i>	104.0	0.00	0.0	low
<i>crop area used</i>	5.2	1.90	0.6	low
<i>pasture area used</i>	700.4	251.50	0.6	low
<i>rice area used</i>	0.4	0.20	1.0	low
<i>import crop</i>	0.0	0.00	0.0	low
<i>import pasture</i>	0.0	0.00	0.0	low
<i>import rice</i>	0.0	0.00	0.0	low
<i>total numbers of cows</i>	189400.0	71940.00	0.6	low
<i>long transhumance cows</i>	24000.0	12000.00	1.0	low
<i>short transhumance cows</i>	36000.0	7440.00	0.3	low
<i>pastoral dairy cows</i>	6000.0	2000.00	0.5	low
<i>specialized dairy cows</i>	2400.0	1000.00	0.7	low
<i>fattening cows</i>	110000.0	55000.00	1.0	low
<i>draft animals</i>	23000.0	500.00	0.0	low

Water impact



	result	difference	percent	evaluation
<i>total water consumption</i>	2.203608e+08	81722669.000	58.9	high
<i>difference between water consumption and rainfall</i>	1.633878e+06	-81723.000	-4.8	low
<i>water consumption per cow</i>	1.163000e+03	-17.000	-1.4	low
<i>water consumption per ton of milk</i>	3.672700e+04	243.000	0.7	low
<i>water consumption per ton of meat</i>	1.240800e+04	-1910.000	-13.3	low
<i>average water consumption intensity</i>	1.190000e-01	0.044	58.7	high

Greenhouse gas emissions

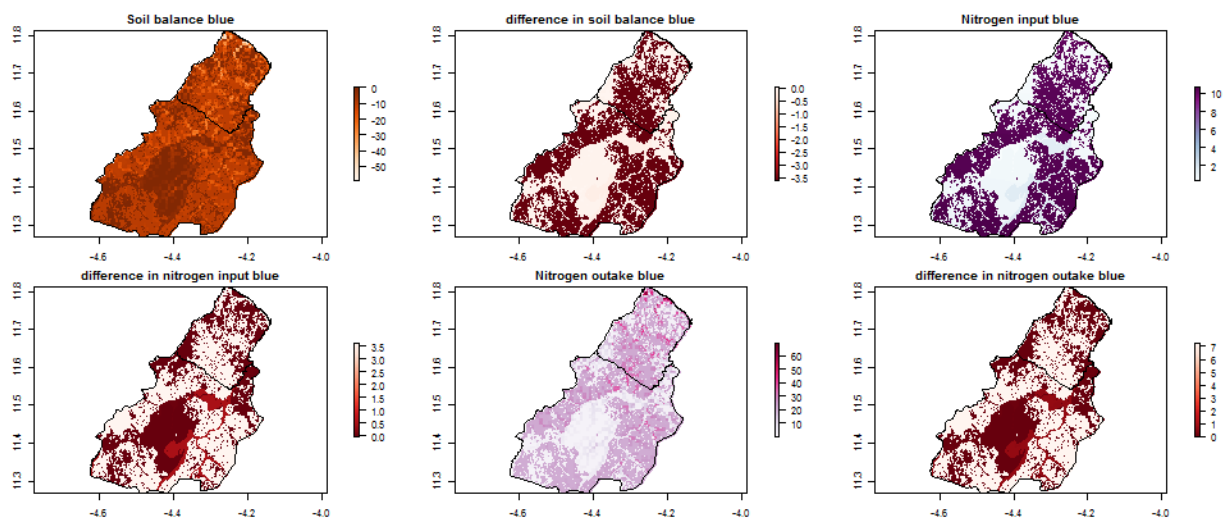


	result	difference	percent	evaluation
<i>CO2 emissions</i>	373033488	141931041	61.4	high
<i>CO2 from manure</i>	143682299	57304020	66.3	high
<i>CO2 from interic fermetation</i>	229434230	84627020	58.4	high
<i>CO2 per cow</i>	1970	3	0.2	low
<i>CO2 per tonnes of milk</i>	62172	1356	2.2	low
<i>CO2 per tonnes of meat</i>	21004	-2864	-12.0	low

Biodiversity

Same as green group

Soil health

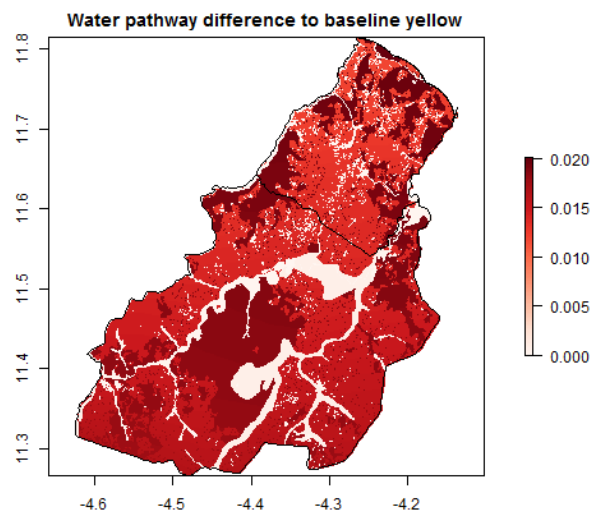
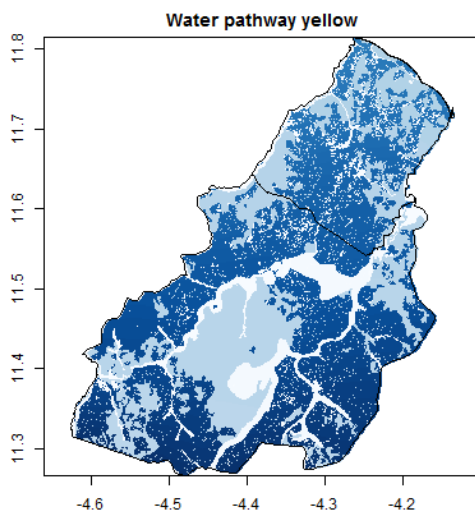


	result	difference	percent	evaluation
<i>nitrogen balance</i>	-1.22495e+07	-105298.000	0.9	low
<i>total nitrogen added</i>	9.27330e+04	18912.000	25.6	low
<i>nitrogen added per cow</i>	7.46000e-01	0.118	18.8	high

6.5.3 Meat and milk processors (Yellow group) *Productivity*

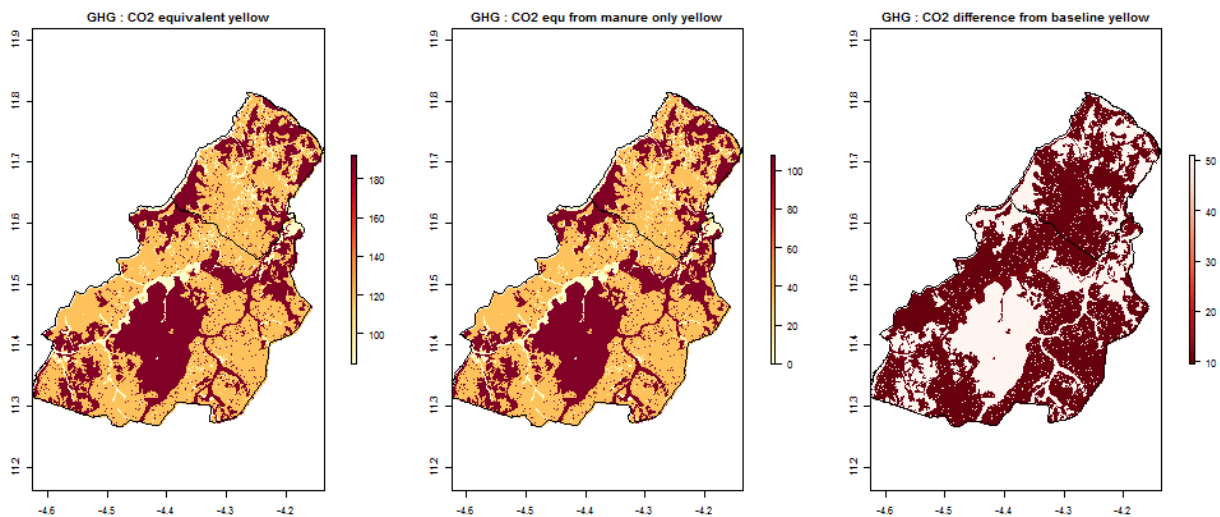
	base	diff	percent	evaluation
<i>meat produced</i>	14568.0	4885.44	0.5	low
<i>milk produced</i>	2600.0	-1200.00	-0.3	low
<i>total area available for crop</i>	556.0	0.00	0.0	low
<i>total area available for pasture</i>	830.0	0.00	0.0	low
<i>total available area for rice</i>	104.0	0.00	0.0	low
<i>crop area used</i>	3.8	0.50	0.2	low
<i>pasture area used</i>	502.3	53.40	0.1	low
<i>rice area used</i>	0.3	0.10	0.5	low
<i>import crop</i>	0.0	0.00	0.0	low
<i>import pasture</i>	0.0	0.00	0.0	low
<i>import rice</i>	0.0	0.00	0.0	low
<i>total numbers of cows</i>	140400.0	22940.00	0.2	low
<i>long transhumance cows</i>	6000.0	-6000.00	-0.5	low
<i>short transhumance cows</i>	12000.0	-16560.00	-0.6	low
<i>pastoral dairy cows</i>	2000.0	-2000.00	-0.5	low
<i>specialized dairy cows</i>	1400.0	0.00	0.0	low
<i>fattening cows</i>	110000.0	55000.00	1.0	low
<i>draft animals</i>	12000.0	-10500.00	-0.5	low

Water impact



	result	difference	percent	evaluation
<i>total water consumption</i>	1.642795e+08	25641358.000	18.5	high
<i>difference between water consumption and rainfall</i>	1.689960e+06	-25641.000	-1.5	low
<i>water consumption per cow</i>	1.170000e+03	-10.000	-0.8	low
<i>water consumption per ton of milk</i>	6.318400e+04	26700.000	73.2	high
<i>water consumption per ton of meat</i>	1.127700e+04	-3041.000	-21.2	low
<i>average water consumption intensity</i>	8.800000e-02	0.013	17.3	high

Greenhouse gas emissions

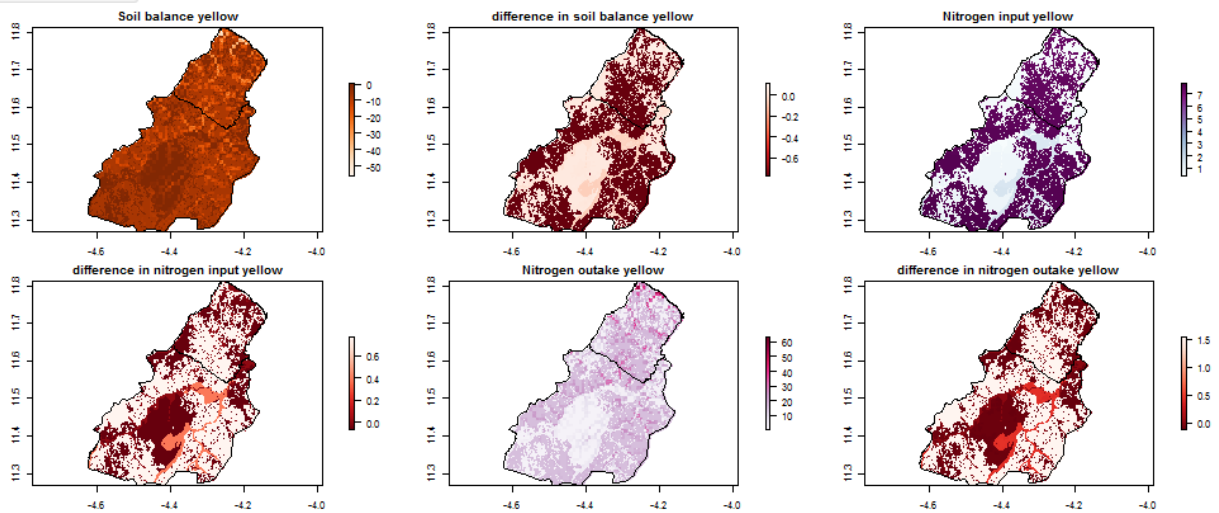


	result	difference	percent	evaluation
<i>CO2 emmissions</i>	280277370	49174923	21.3	high
<i>CO2 from manure</i>	115372315	28994036	33.6	high
<i>CO2 from interic fermetation</i>	164988097	20180887	13.9	high
<i>CO2 per cow</i>	1996	29	1.5	low
<i>CO2 per tonnes of milk</i>	107799	46983	77.3	high
<i>CO2 per tonnes of meat</i>	19239	-4629	-19.4	low

Biodiversity

Same as green group

Soil health

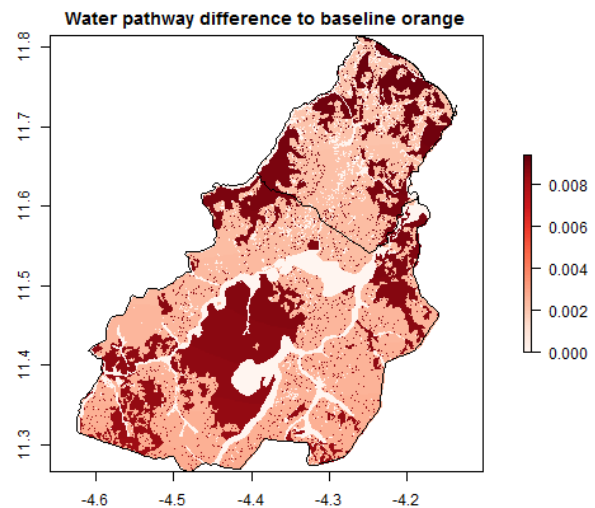
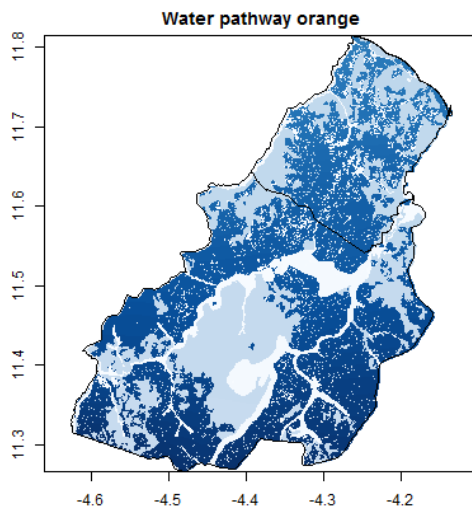


	result	difference	percent	evaluation
<i>nitrogen balance</i>	-9801605.000	2342594.000	-19.3	low
<i>total nitrogen added</i>	65844.000	-7977.000	-10.8	low
<i>nitrogen added per cow</i>	0.789	0.161	25.6	high

6.5.4 Ministry representatives and district administration (Orange group) *Productivity*

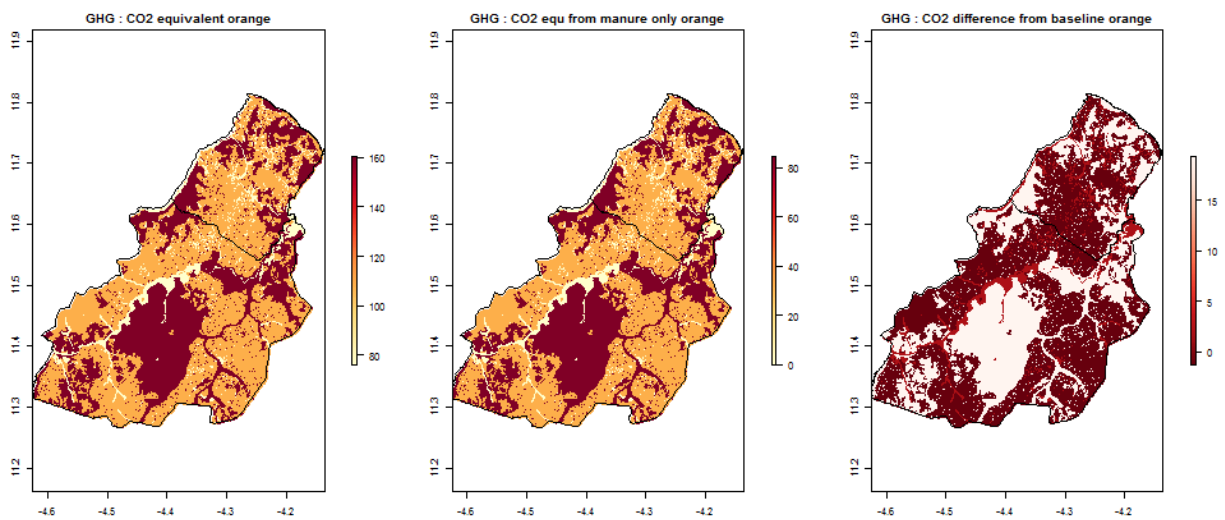
	base	diff	percent	evaluation
<i>meat produced</i>	12057.6	2375.04	0.2	low
<i>milk produced</i>	3600.0	-200.00	-0.1	low
<i>total area available for crop</i>	556.0	0.00	0.0	low
<i>total area available for pasture</i>	830.0	0.00	0.0	low
<i>total available area for rice</i>	104.0	0.00	0.0	low
<i>crop area used</i>	3.4	0.10	0.0	low
<i>pasture area used</i>	457.7	8.80	0.0	low
<i>rice area used</i>	0.2	0.00	0.0	low
<i>import crop</i>	0.0	0.00	0.0	low
<i>import pasture</i>	0.0	0.00	0.0	low
<i>import rice</i>	0.0	0.00	0.0	low
<i>total numbers of cows</i>	124320.0	6860.00	0.1	low
<i>long transhumance cows</i>	8160.0	-3840.00	-0.3	low
<i>short transhumance cows</i>	19440.0	-9120.00	-0.3	low
<i>pastoral dairy cows</i>	3000.0	-1000.00	-0.2	low
<i>specialized dairy cows</i>	1800.0	400.00	0.3	low
<i>fattening cows</i>	83000.0	28000.00	0.5	low
<i>draft animals</i>	13000.0	-9500.00	-0.4	low

Water impact



	result	difference	percent	evaluation
<i>total water consumption</i>	1.461757e+08	7537596.000	5.4	low
<i>difference between water consumption and rainfall</i>	1.708064e+06	-7537.000	-0.4	low
<i>water consumption per cow</i>	1.176000e+03	-4.000	-0.3	low
<i>water consumption per ton of milk</i>	4.060400e+04	4120.000	11.3	low
<i>water consumption per ton of meat</i>	1.212300e+04	-2195.000	-15.3	low
<i>average water consumption intensity</i>	7.900000e-02	0.004	5.3	low

Greenhouse gas emissions

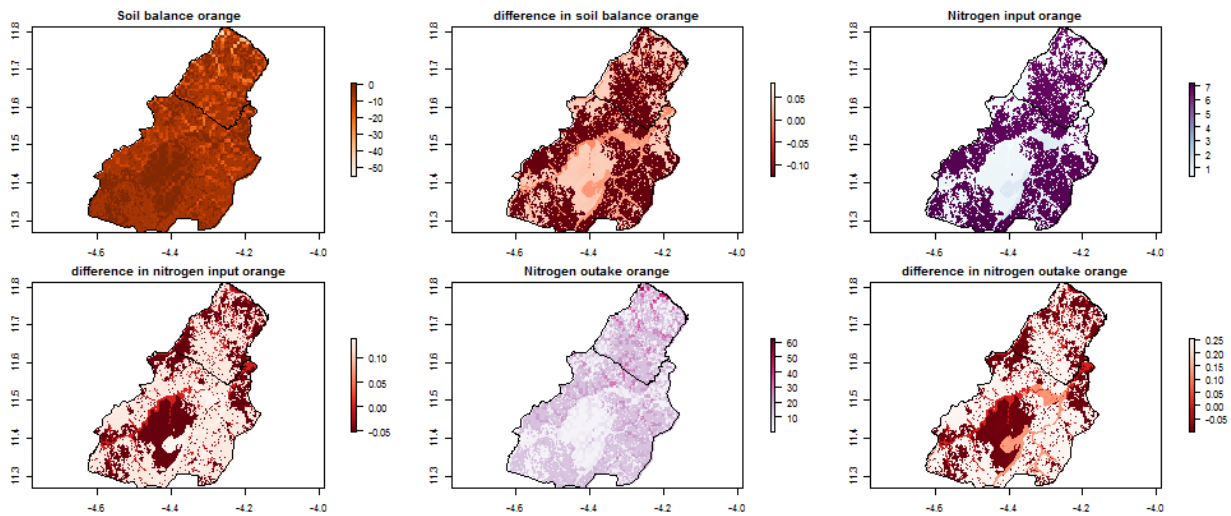


	result	difference	percent	evaluation
<i>CO2 emmissions</i>	244214050	13111603	5.7	low
<i>CO2 from manure</i>	95975225	9596946	11.1	low
<i>CO2 from interic fermetation</i>	148321867	3514657	2.4	low
<i>CO2 per cow</i>	1964	-3	-0.2	low
<i>CO2 per tonnes of milk</i>	67837	7021	11.5	low
<i>CO2 per tonnes of meat</i>	20254	-3614	-15.1	low

Biodiversity

Same as Green group

Soil health



	result	difference	percent	evaluation
<i>nitrogen balance</i>	-11094815.000	1049384.000	-8.6	low
<i>total nitrogen added</i>	85878.000	12057.000	16.3	low
<i>nitrogen added per cow</i>	0.824	0.196	31.2	high

6.6 CLEANED output for the heterogenous stakeholder group scenarios

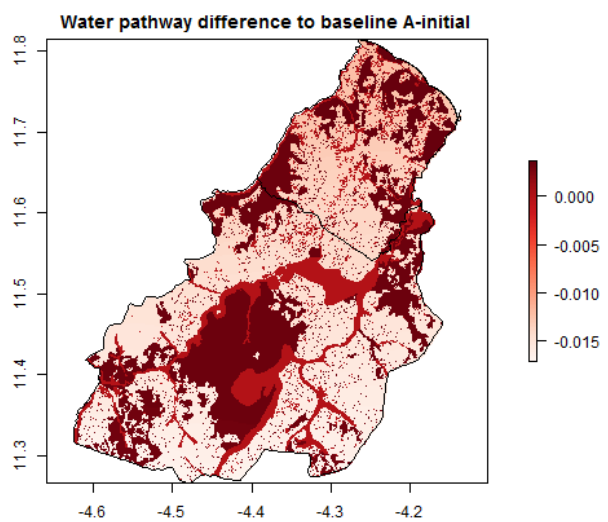
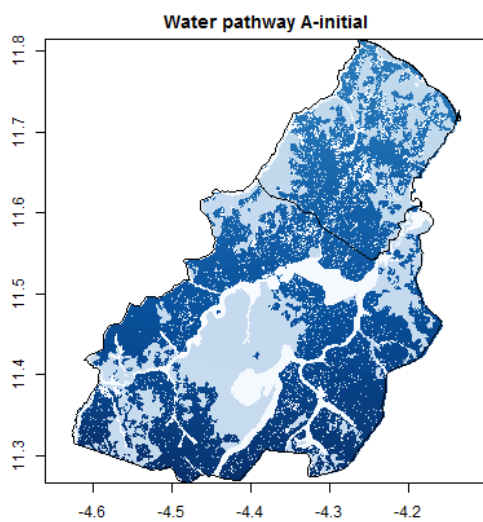
Detailed CLEANED results for the 4 scenarios on Day 2 – initial and revised from each of the two groups – not just the summary results used on the scorecards

6.6.1 Group A : initial scenario

Productivity

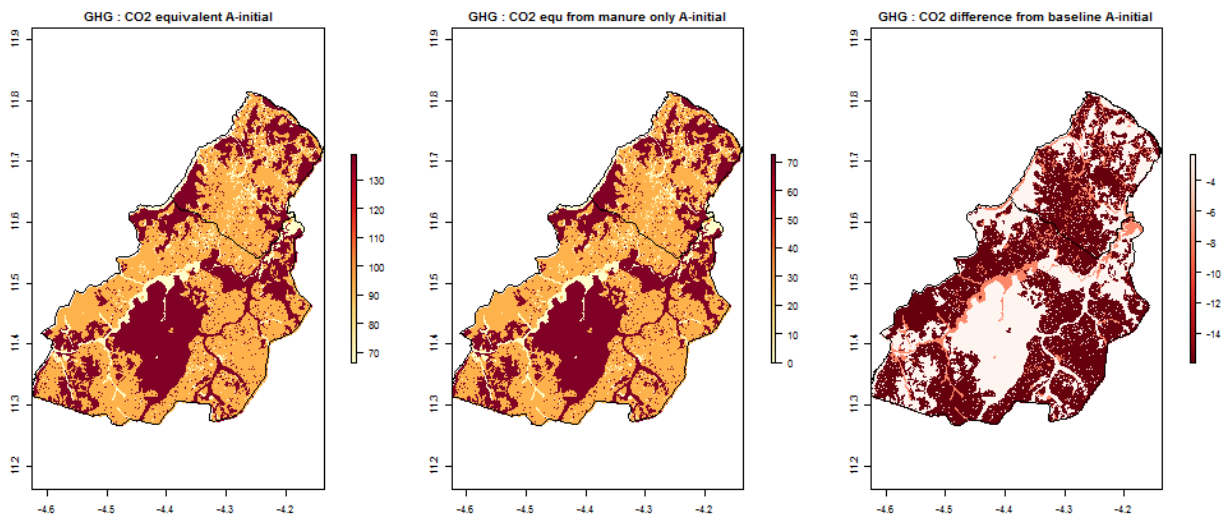
	base	diff	percent	evaluation
<i>meat produced</i>	10406.4	723.84	0.1	low
<i>milk produced</i>	3100.0	-700.00	-0.2	low
<i>total area available for crop</i>	556.0	0.00	0.0	low
<i>total area available for pasture</i>	830.0	0.00	0.0	low
<i>total available area for rice</i>	104.0	0.00	0.0	low
<i>crop area used</i>	2.9	-0.40	-0.1	low
<i>pasture area used</i>	394.4	-54.50	-0.1	low
<i>rice area used</i>	0.2	0.00	0.0	low
<i>import crop</i>	0.0	0.00	0.0	low
<i>import pasture</i>	0.0	0.00	0.0	low
<i>import rice</i>	0.0	0.00	0.0	low
<i>total numbers of cows</i>	107900.0	-9560.00	-0.1	low
<i>long transhumance cows</i>	10200.0	-1800.00	-0.2	low
<i>short transhumance cows</i>	16200.0	-12360.00	-0.4	low
<i>pastoral dairy cows</i>	2500.0	-1500.00	-0.4	low
<i>specialized dairy cows</i>	1600.0	200.00	0.1	low
<i>fattening cows</i>	70000.0	15000.00	0.3	low
<i>draft animals</i>	12500.0	-10000.00	-0.4	low

Water impact



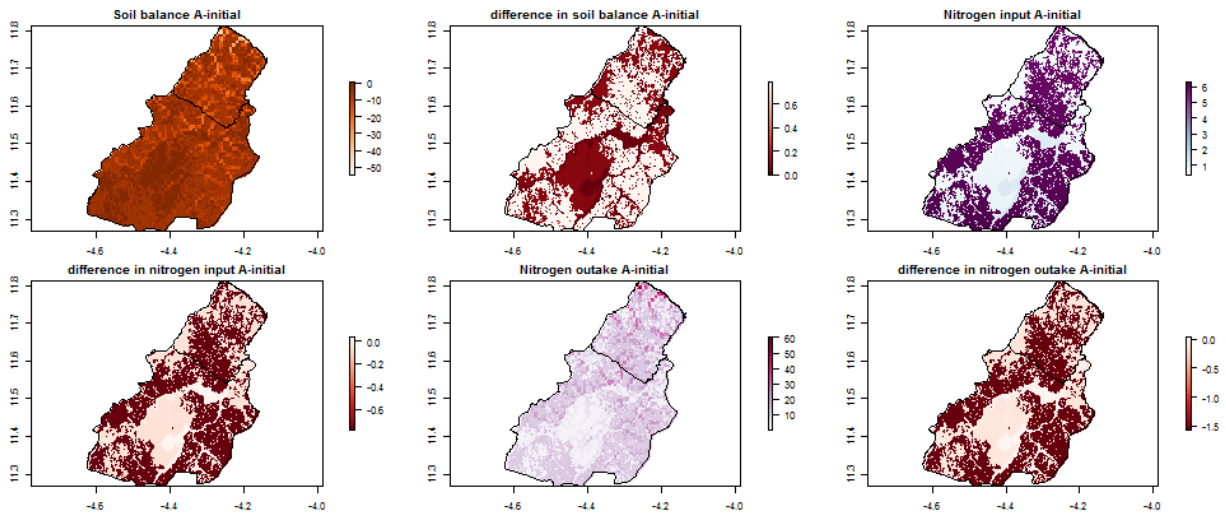
	result	difference	percent	evaluation
<i>total water consumption</i>	1.257779e+08	-12860171.000	-9.3	low
<i>difference between water consumption and rainfall</i>	1.728461e+06	12860.000	0.7	low
<i>water consumption per cow</i>	1.166000e+03	-14.000	-1.2	low
<i>water consumption per ton of milk</i>	4.057400e+04	4090.000	11.2	low
<i>water consumption per ton of meat</i>	1.208700e+04	-2231.000	-15.6	low
<i>average water consumption intensity</i>	6.800000e-02	-0.007	-9.3	low

Greenhouse gas emission



	result	difference	percent	evaluation
<i>CO2 emmissions</i>	211325097	-19777350	-8.6	low
<i>CO2 from manure</i>	81853042	-4525237	-5.2	low
<i>CO2 from interic fermetation</i>	129555097	-15252113	-10.5	low
<i>CO2 per cow</i>	1959	-8	-0.4	low
<i>CO2 per tonnes of milk</i>	68169	7353	12.1	low
<i>CO2 per tonnes of meat</i>	20307	-3561	-14.9	low

Soil health



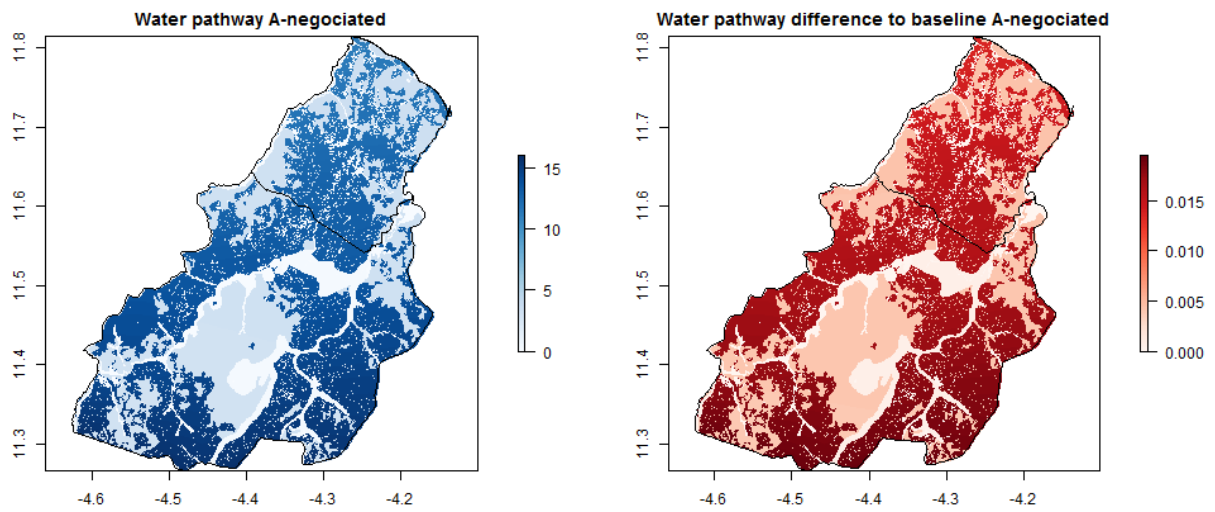
	result	difference	percent	evaluation
<i>nitrogen balance</i>	-15973137.000	-3828938.00	31.5	high
<i>total nitrogen added</i>	124690.000	50869.00	68.9	high
<i>nitrogen added per cow</i>	0.658	0.03	4.8	low

6.6.2 Group A : negotiated scenario

Productivity

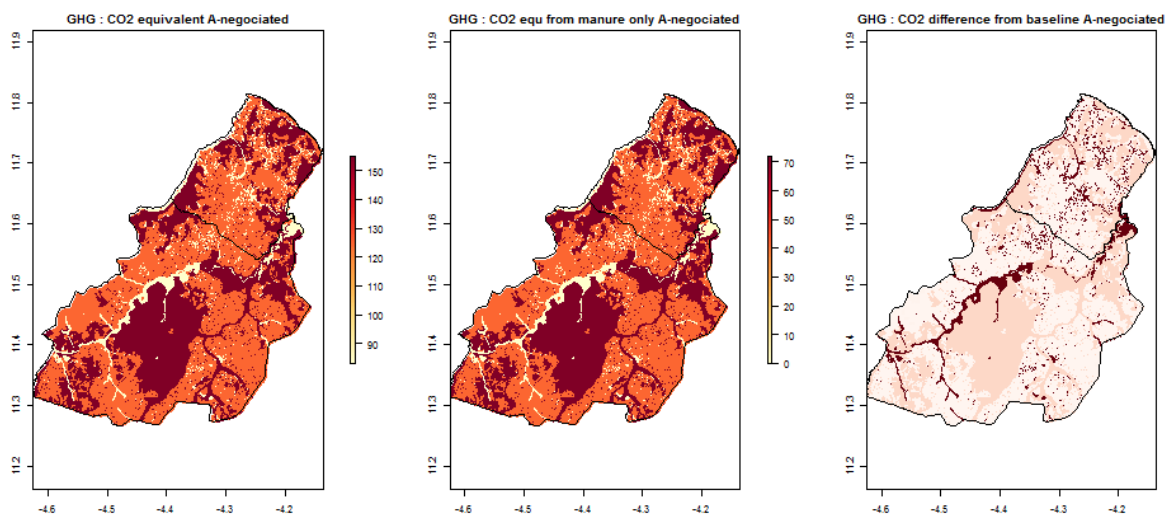
	base	diff	percent	evaluation
<i>meat produced</i>	12412.8	2730.24	0.3	low
<i>milk produced</i>	4870.0	1070.00	0.3	low
<i>total area available for crop</i>	556.0	0.00	0.0	low
<i>total area available for pasture</i>	830.0	0.00	0.0	low
<i>total available area for rice</i>	104.0	0.00	0.0	low
<i>crop area used</i>	3.7	0.40	0.1	low
<i>pasture area used</i>	511.3	62.40	0.1	low
<i>rice area used</i>	0.3	0.10	0.5	low
<i>import crop</i>	0.0	0.00	0.0	low
<i>import pasture</i>	0.0	0.00	0.0	low
<i>import rice</i>	0.0	0.00	0.0	low
<i>total numbers of cows</i>	134450.0	16990.00	0.1	low
<i>long transhumance cows</i>	15600.0	3600.00	0.3	low
<i>short transhumance cows</i>	37200.0	8640.00	0.3	low
<i>pastoral dairy cows</i>	5200.0	1200.00	0.3	low
<i>specialized dairy cows</i>	1750.0	350.00	0.2	low
<i>fattening cows</i>	70000.0	15000.00	0.3	low
<i>draft animals</i>	12500.0	-10000.00	-0.4	low

Water impact



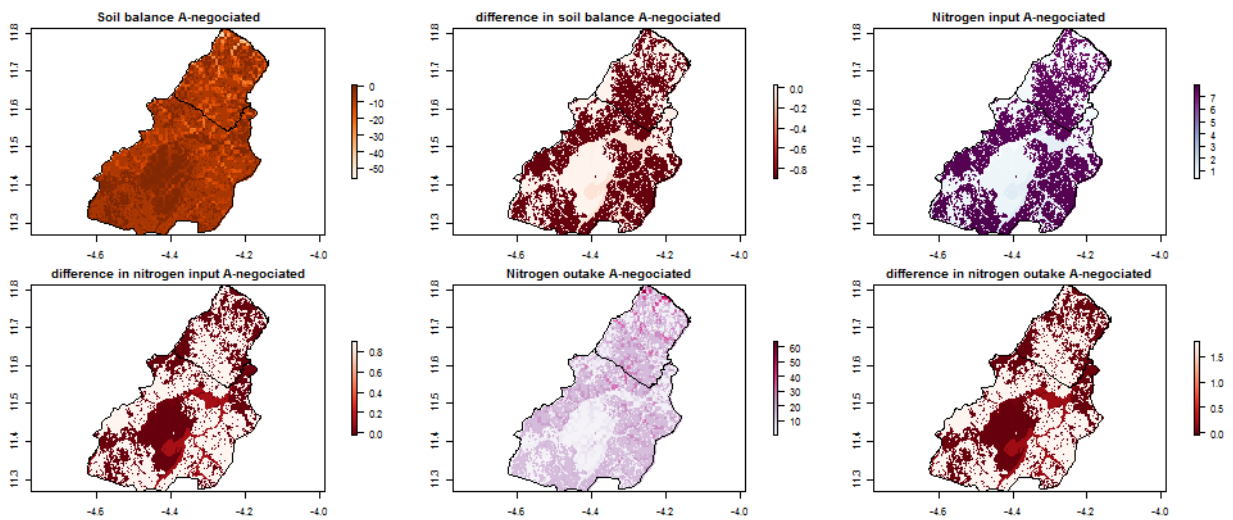
	result	difference	percent	evaluation
<i>total water consumption</i>	1.581410e+08	19502901.00	14.1	high
<i>difference between water consumption and rainfall</i>	1.696098e+06	-19503.00	-1.1	low
<i>water consumption per cow</i>	1.176000e+03	-4.00	-0.3	low
<i>water consumption per ton of milk</i>	3.247200e+04	-4012.00	-11.0	low
<i>water consumption per ton of meat</i>	1.274000e+04	-1578.00	-11.0	low
<i>average water consumption intensity</i>	8.500000e-02	0.01	13.3	high

Greenhouse gas emission



	result	difference	percent	evaluation
<i>CO2 emmissions</i>	258331055	27228608	11.8	high
<i>CO2 from manure</i>	96222342	9844063	11.4	low
<i>CO2 from interic fermetation</i>	162191755	17384545	12.0	high
<i>CO2 per cow</i>	1921	-46	-2.3	low
<i>CO2 per tonnes of milk</i>	53045	-7771	-12.8	low
<i>CO2 per tonnes of meat</i>	20812	-3056	-12.8	low

Soil health



	result	difference	percent	evaluation
<i>nitrogen balance</i>	-13086428.000	-942229.000	7.8	high
<i>total nitrogen added</i>	78472.000	4651.000	6.3	low
<i>nitrogen added per cow</i>	0.584	-0.044	-7.0	low

6.6.3 Group B : initial scenario

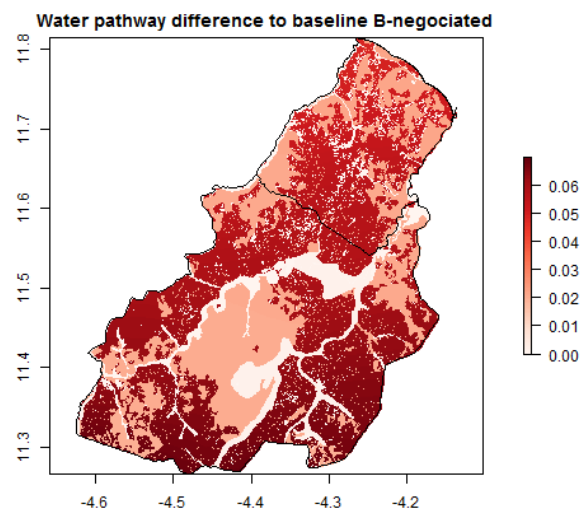
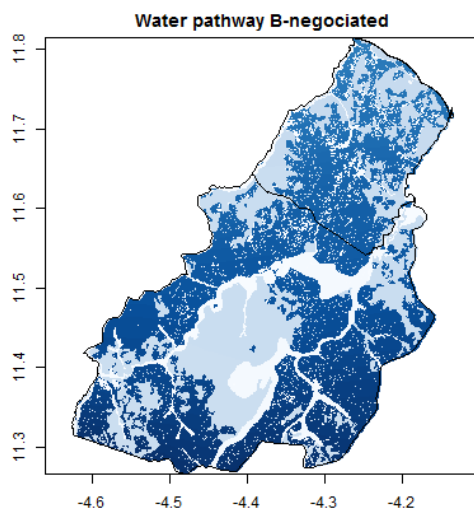
Same as blue group see section 6.5.2

6.6.4 Group B : negotiated scenarios

Productivity

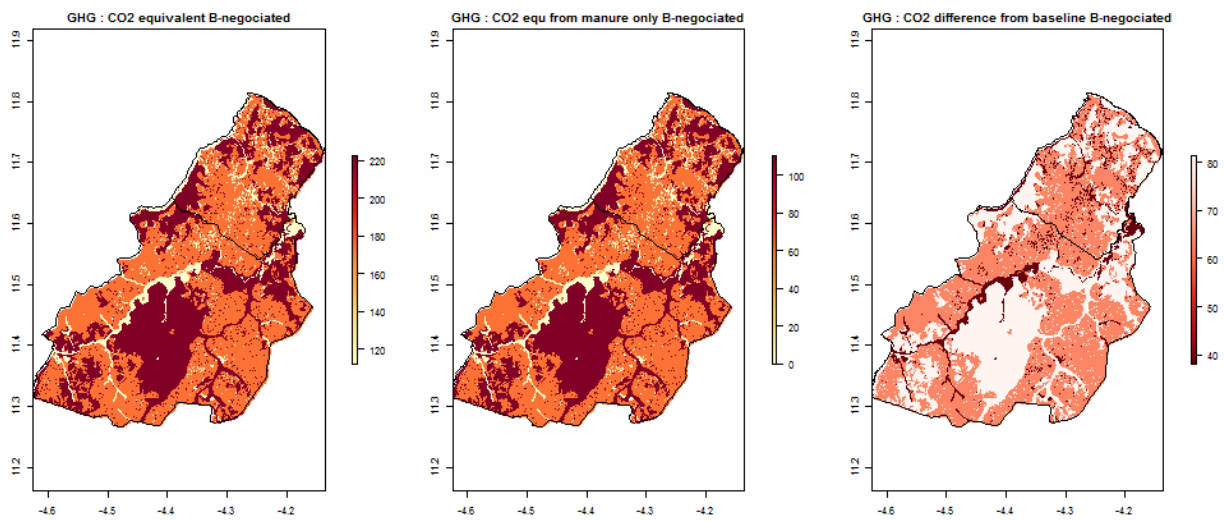
	base	diff	percent	evaluation
<i>meat produced</i>	17760.0	8077.44	0.8	low
<i>milk produced</i>	5000.0	1200.00	0.3	low
<i>total area available for crop</i>	556.0	0.00	0.0	low
<i>total area available for pasture</i>	830.0	0.00	0.0	low
<i>total available area for rice</i>	104.0	0.00	0.0	low
<i>crop area used</i>	5.0	1.70	0.5	low
<i>pasture area used</i>	671.6	222.70	0.5	low
<i>rice area used</i>	0.4	0.20	1.0	low
<i>import crop</i>	0.0	0.00	0.0	low
<i>import pasture</i>	0.0	0.00	0.0	low
<i>import rice</i>	0.0	0.00	0.0	low
<i>total numbers of cows</i>	182400.0	64940.00	0.6	low
<i>long transhumance cows</i>	24000.0	12000.00	1.0	low
<i>short transhumance cows</i>	36000.0	7440.00	0.3	low
<i>pastoral dairy cows</i>	6000.0	2000.00	0.5	low
<i>specialized dairy cows</i>	1400.0	0.00	0.0	low
<i>fattening cows</i>	110000.0	55000.00	1.0	low
<i>draft animals</i>	17000.0	-5500.00	-0.2	low

Water impact



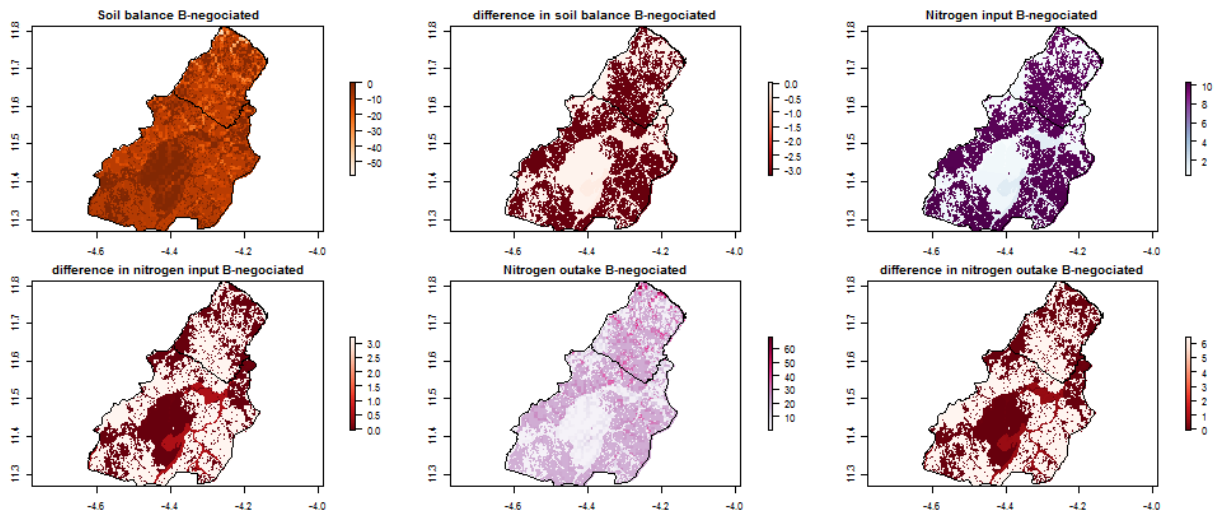
	result	difference	percent	evaluation
<i>total water consumption</i>	2.116443e+08	73006199.000	52.7	high
<i>difference between water consumption and rainfall</i>	1.642595e+06	-73006.000	-4.3	low
<i>water consumption per cow</i>	1.160000e+03	-20.000	-1.7	low
<i>water consumption per ton of milk</i>	4.232900e+04	5845.000	16.0	low
<i>water consumption per ton of meat</i>	1.191700e+04	-2401.000	-16.8	low
<i>average water consumption intensity</i>	1.140000e-01	0.039	52.0	high

Greenhouse gas emission



	result	difference	percent	evaluation
<i>CO2 emissions</i>	364022535	132920088	57.5	high
<i>CO2 from manure</i>	144944119	58565840	67.8	high
<i>CO2 from interic fermetation</i>	219161458	74354248	51.3	high
<i>CO2 per cow</i>	1996	29	1.5	low
<i>CO2 per tonnes of milk</i>	72805	11989	19.7	high
<i>CO2 per tonnes of meat</i>	20497	-3371	-14.1	low

Soil health



	result	difference	percent	evaluation
<i>nitrogen balance</i>	-15529129.000	-3384930.000	27.9	high
<i>total nitrogen added</i>	118052.000	44231.000	59.9	high
<i>nitrogen added per cow</i>	0.647	0.019	3.0	low