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Final Dissertation

Food Security and Conflicts: the case of Liptako-Gourma

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I would love to dedicate this work to my dad Giancarlo, my mum Cristina, my brother Andrea and to all my friends.

Contents

Abstract

The student's internship at FAO-REOWA (Regional Resilience, Emergency and Rehabilitation Office for West Africa/Sahel) in Dakar, Senegal allowed to draw the foundations of this study.

Understanding how food security and violent conflicts interact is crucial to provide humanitarian aid in afflicted countries. Liptako-Gourma, a landlocked area in the Sahel semi-desert, is an historic bordering zone where various ethnic groups converged, sometimes engaging in conflicts. Longstanding tensions amplified into assaults and clashes since 2018.

This analysis exposes how food security and conflicts interact in the area of Liptako-Gourma at local level. We gathered open data describing six dimensions of the food insecurity-conflict vicious cycle: food security, food access, food stability, conflict size, conflict severity and IDPs size. We identified the most afflicted provinces assessing the dimensions evolution through the years since 2014. Furthermore we studied the correlation between the dimensions in the wider context of Liptako-Gourma.

The analysis shows that the dimensions of food security, conflict size, conflict severity and IDPs size are solidly correlated with each other. Food access and stability lacked crucial open data. This dimensions as described are uncorrelated from food security, conflict and IDPs dimensions. The lack of open data limited the study in the construction of several dimensions.

This study concludes that the food security-conflict vicious cycle that is hampering the region of Liptako-Gourma, feeds himself and external effort is needed. The plan of humanitarian intervention with the intent of strengthening the resilience of the region is crucial to break the vicious cycle of food security and conflict.

1 Literature Review

Food insecurity could be a crucial factor in the foundations of a violent conflict. Violent conflict hurts food security of countries with poor infrastructure and adversary climate. Food insecurity and violent conflict together shape a fiery vicious cycle that feeds itself. In this type of situation food prices and internal displaced persons (IDPs) are interested first. This analysis exposes how food security and conflicts interact in the area of Liptako-Gourma at local level. It could be helpful to plan humanitarian intervention in a way to strengthen the resilience of the region.

1.1 Area Description

1.1.1 Demographics

The studied area is cross-border between Burkina Faso, Mali and Niger located in the Sahelian belt of Africa. The region is called Liptako-Gourma. This study covers 32 administrative level two area subzones belonging to 8 administrative regions in 3 countries. The area extends for 524,000 km^2 populated by 9.44 million people.

The focus of the study is to provide useful information at the administrative level two areas which could be utilized to better understand the local realities situation. The administrative region included in this study is:

- Burkina Faso: a part of Est region, a part of Nord region, Sahel region
- Mali: Gao region, Mopti region, a part of Tombouctou region
- Niger: a part of Tahoua region, a part of Tillaberi region

As shown in the map in Figure 1.1

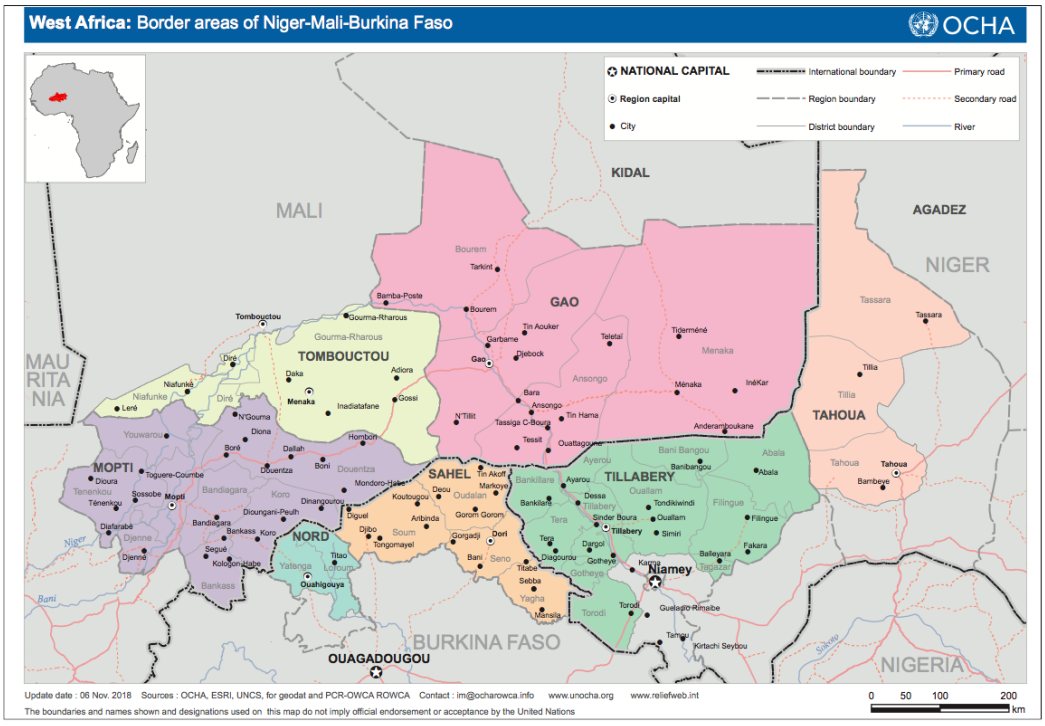

Figure 1.1: Area of Study Map[13]

Administrative two areas (provinces for Burkina Faso, cercles for Mali and departments for Niger) in this study will all be called provinces. In Table 1.2 for each province is given the name (`adm2_name`), region (`adm1_name`), country (`adm0_name`), area extension in squared kilometers[15] (`area`) and population in 2020[17] (`population`).

	adm0_name	adm1_name	adm2_name	area	population
0	Burkina Faso	Est	Komonjdjari	5089	105540
1	Burkina Faso	Nord	Loroum	3700	177109
2	Burkina Faso	Nord	Yatenga	6807	678703
3	Burkina Faso	Sahel	Oudalan	10062	251998
4	Burkina Faso	Sahel	Seno	7008	331150
5	Burkina Faso	Sahel	Soum	12630	440647
6	Burkina Faso	Sahel	Yagha	6489	203315
7	Mali	Gao	Ansongo	23037	157184
8	Mali	Gao	Bourem	42655	138610
9	Mali	Gao	Gao	34429	285337
10	Mali	Gao	Menaka	76745	64869
11	Mali	Mopti	Bandiagara	7967	373461
12	Mali	Mopti	Bankass	6218	315462
13	Mali	Mopti	Djenne	4495	248309
14	Mali	Mopti	Douentza	23223	293836
15	Mali	Mopti	Koro	10633	431997
16	Mali	Mopti	Mopti	7242	439524
17	Mali	Mopti	Tenenkou	11469	194113
18	Mali	Mopti	Youwarou	8009	229298
19	Mali	Tombouctou	Dire	2406	130659
20	Mali	Tombouctou	Gourma-Rharous	42475	132293
21	Mali	Tombouctou	Niafunke	8785	209035
22	Niger	Tahoua	Tahoua	12270	466127
23	Niger	Tahoua	Tassara	40722	180274
24	Niger	Tahoua	Tillia	17873	41930
25	Niger	Tillaberi	Banibangou	6550	68524
26	Niger	Tillaberi	Filingue	23998	595059
27	Niger	Tillaberi	Kollo	8916	499408
28	Niger	Tillaberi	Ouallam	14604	347682
29	Niger	Tillaberi	Say	13761	389966
30	Niger	Tillaberi	Tera	10934	452905
31	Niger	Tillaberi	Tillaberi	12344	560655
32	Tot. Liptako-Gourma:			523548	9434979

Figure 1.2: Provinces of Liptako-Gourma considered in the study

1.1.2 Socio-Economic Conditions

The majority of the population lives in the south of the region where it is easier to have water access. Sedentary groups here are mostly found near the valley of the Niger river and its tributaries. Being almost entirely arid, the north of the region is less densely populated. Nomads are the only who hold these territories. Nearly 90% of the Liptako-Gourma population lives in a rural zone. The demographic growth is high (from 2014 to 2020 averaging 3% a year), which translates into 50% of

the population being 15 or younger.[13]

The agricultural production is very limited in the regions of Gao, Tombouctou, and Sahel, as well as in the north part of Tahoua due to climatic harshness. The agricultural production represents a marginal factor in the economy of these places. Instead in the regions of Mopti and Tillaberi, the Niger river, several reservoirs and ponds allow to irrigate cultivation and water livestock. In all the border area crops mainly consist of extensive type cereal (millet, sorghum and rice).

Traditional livestock is a vital part of the economy of Gao, Tahoua and Tombouctou regions. Fishing is practiced in the Mopti region near the Niger river, but it is not prevailing. The economy in Liptako-Gourma is better described as agro-pastoral on subsistence crops and livestock.
A livelihood map is shown in Figure 1.3

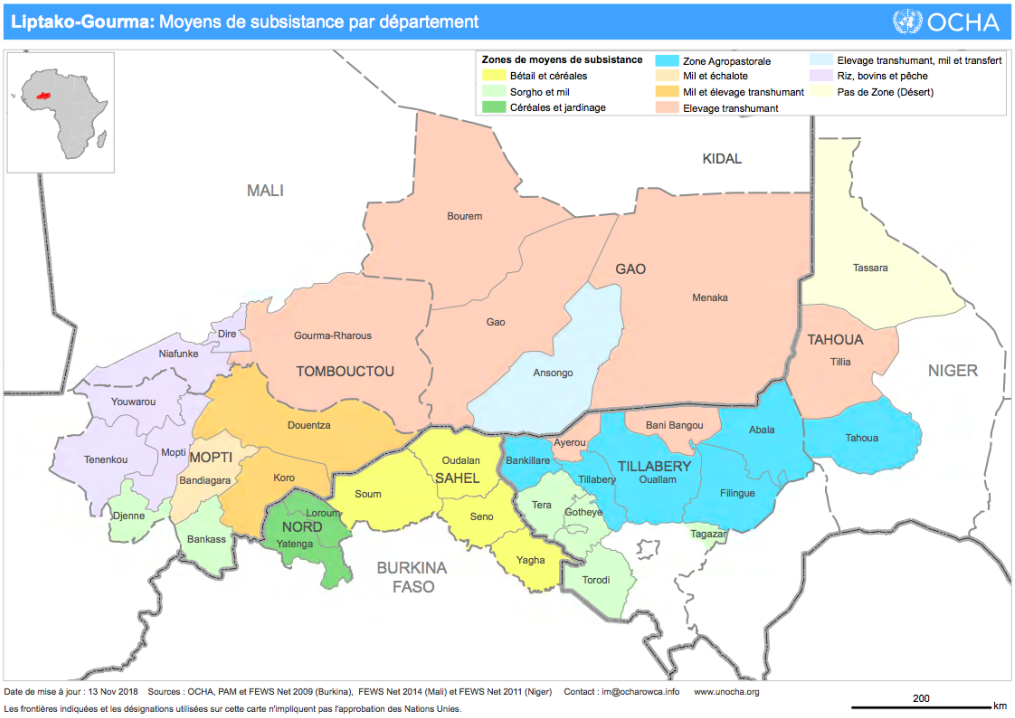

Figure 1.3: Livelihood Map[13]

1.1.3 General Context

During 2012-2013 Malian crisis, the government lost control of the north part of the country to Tuareg groups from Azaward. In 2015 was signed a peace agreement by pro-government Groupe Autodenfense Touareg Imghad et Allies and anti-government group Azawad Movement Coalition. Slow disarmament is responsible for still active tensions between the groups.[2]

In northern Mali access to land and water nourished local tension between Dogon (pastoral farmer) and Fulani (nomadic herders) for decades. Authorities applying traditional methods often manage to find momentary solutions. In 2018 Extremist groups used the lack of strong local authorities to drive attacks and animate intercommunal conflicts.[2]

Violence spilled over the borders of Mali into Burkina Faso and Niger. The more conflicts increased in frequency the more they spread from urban to rural settings.

The lack of local governance left the population with the only hope of creating self-defence militias. In Mali the militias of Dan Na Ambassagou take control over tactical checkpoints limiting transportation. Both prime ministers of Burkina Faso and Mali resign in 2019 as an outcome of their incapability in crises addressing.[3] The self-defence militias became ethnic militias and they started to raid and attack other ethnic groups causing more turbulence. It is difficult to differentiate which attacks are perpetrated by extremist groups and which by civil militias. Often the attacks from both groups have the same targets: civilians and public infrastructures like medical facilities, markets, churches, schools, roads and bridges.

Islamist groups have often recruited from Fulani communities. Burkina Faso forces are accused of violating civil rights executing suspected jihadists from the Fulani population during operations to counter terrorism.[1]

IDPs chose to abandon all their belongings and food stocks (fields and livestock). Primarily because humanitarian organizations could not access their territories, targeted by conflicts and climatic events. Even where they are displaced it is not easy for them to access aid and basic services. Often IDPs are the target of both extremist groups and governmental forces.

Extreme weather destroys roads and houses. Dry spells, heavy rainfall and floods spoil harvest and reduce agricultural production every year. Access to markets and fields is decreased due to risk of attacks. Livestock thefts are frequent. Climatic change and instability cause changes in transhumance patterns which will trigger more confrontations between herders and farmers. In regions where an high number of IDPs are hosted, resources risk to be out of stock. The competition over resources will only drive the prices even higher.[4]

Access to the region is problematic for humanitarian actors. Insecurity and poor infrastructures restrict humanitarian operations.

To avoid the spread of COVID-19 governments imposed heavy quarantine and circulation restrictions. These brought a decline in public services, humanitarian operations and a further hampered economic activity leading to massive job losses.[4]
Governments are not able to restore stability. The main liabilities[4] are:

- Poor trained and equipped security forces
- Longstanding lack of local governance
- Limited chains of command within local armed groups and militias

1.2 Food Security

1.2.1 The Four Pillars

As stated in the Rome Declaration on World Food Security at the World Food Summit 1996:[18]

> Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

Here the multidimensional nature of food security is clearly palpable. The pillars are food access, availability, use and stability. FAO categorizes Food Security for population, households or individuals. The FAO Food Security definition points out its four dimensions:[11]

- **Food Availability**: Sufficient volume of calories and nutrients intake and calories and nutrients nature variety (e.g. carbohydrates, proteins, fats and micronutrients).
- **Food Access**: Physical infrastructure that allows to grow, harvest, store, transport, sell and buy diversity of food.
- **Food Utilization**: Knowledge and usage of available calories. Clean water, sanitation and health care are essential to provide an adequate diet.
- **Food Stability**: Resilience towards sudden shocks (e.g. epidemic, economic or climatic crisis) or cyclical events (e.g. lean season) prevents losing access to food.

1.2.2 Food Security Drivers

Each pillar is influenced by multiple drivers. Each driver can be a limit or a resource into reaching food security.[11] [10]
Availability

- food production and consumption (diversity and per capita)

- food prices (mean and major changes)
- protein supply (total and animal, per capita)

Access

- live green vegetation presence
- clean water access and rainfall
- local political equity (land access)
- agricultural inputs: seeds, fertilizers, tools (availability, prices and usage)
- agriculture and rural development

Utilization

- infrastructure (refrigerators, storage, roads) and food transportation
- education
- health care and food sanitation

Stability

- conflicts and conflict drivers (see 1.3.2)
- natural hazards: locusts, drought, flooding, earthquake, landslides, tsunami, typhoons, eruptions
- human, animal and vegetation diseases
- displacements

1.2.3 Food Insecurity in Liptako-Gourma

In a globalized world landlocked countries are disadvantaged in trades due to the high cost of transportation. Other than underdeveloped infrastructure (roads, railways, airports) for these countries it is significantly harder to benefit of the major transportation: cargo shipping by ocean.[9]
Seen the General Context of Liptako-Gourma in 1.1.3 is possible to highlight some relevant drivers of food insecurity in Liptako-Gourma:

- **Internally Displaced People**
- **Agricultural Vulnerabilities**
- **Livestock Vulnerabilities**
- **Human Diseases**
- **Products Prices**
- **Conflicts**

All the intricate set of consequences complete the vicious cycle of food insecurity and conflicts. Internally displaced people are the result of this cycle, and the beginning of a new one.

1.3 Conflicts

ACLED[5] has defined a precise type for each possible event involving an interaction between designated actors:

- Violent Events
  - Battles
  - Explosions/Remote Violence
  - Violence against Civilians
- Demonstrations
  - Protests (peaceful protest)
  - Riots (violent demonstration)
- Non-violent actions
  - Strategic developments

1.3.1 Food Riots

In countries where people spend majority of their income in food, population is extremely sensible to food price variations. Civilians grouped as a mob can rise into riots moved by survival instinct of starvation if led by a more influential actor.
The World Bank define a "food riot" as:

> "A violent, collective unrest leading to a loss of control, bodily harm or damage to property, essentially motivated by a lack of food availability, accessibility or affordability, as reported by the international media, and which may have other underlying causes of discontent."[7]

From this definition it's helpful to notice 4 components recognizable in a food riot: The first element is "violence" which differentiates riots from peaceful protests or demonstrations.
The second component considers rebellion motivation's directly correlated to food insecurities. Food stock lack and high food prices are solid motivations for those riots.
Often motivations exceed food. Sub-motivations dictated by context can be unemployment, inflation and poorly framed working conditions.
The last requisite to identify a violent revolt as a food riot is collective action.

Food riots are carried on by mob. Being an essential need for humans, food is also a human fundamental right. This is why mob feels justified by rights protection. We are going to observe examples of food riots and a political riot:

- Russian Revolution (1917)[8] was originated by increase in bread prices and rationing of the same. Access was limited by the cold winter leading to terrible harvest and First World War consequences.
- Rice Riots in Japan (1918)[8] were moved by the desire of a fair economy, given the growth of high inflation in those years. The government bought up existing rice stocks for troops committed in the Siberian Intervention, driving rice prices even higher.
- Haiti Food Riot (2008)[9] characterized by a huge price variation of rice, beans and other staples[14]. This riot is identifiable with natural and economic causes.
- Malagasy Political Crisis (2009)[9] instead is a completely different riot driven by political issues. The government was accused by the capital major of diverting investment away from the city, corruption and restriction of freedom of expression.[16]

1.3.2 Conflict Drivers

Stability is often threatened when a multitude of the following factors are present in the same region:[9]

- **Population Growth and Urbanization Tax**: the more a country is highly urbanized, the more it is inclined to riots and insurrections.
- **Competition for Land and Water**
- **Price Volatility**: dependence on imported food does not guarantee self-sufficiency. Harvest production needs quality and quantity of land and agricultural inputs.
- **Climate Change**: frequency of storms, hurricanes, drought, flooding, landslides and variation in annual climate cycles
- **People Marginalization and Governament Stability**: social, socio-economical and political inconsistencies mashed up without integration are problematic to manage.

1.3.3 Conflict Consequences

Conflict has an enormous impact on hunger and poverty. This creates an obvious vicious cycle that without external help can only worsen. Here we consider the most influential consequences:[9]

- **Internally Displaced Persons (IDPs)**: Instinctively people want to avoid conflict so they leave their home or they are forced to leave by the usurpers. IDPs bring with themselves more mouths to be bred, and bodies to be warmed in places where the food is scarce and the structures are needy. Other social groups may not welcome the IDPs arrival.
- **Food Prices Increase**: Direct reaction of land, water, biological and social resource destruction and lower agriculture and environmental protection investments.
- **Food and Economic Insecurity**: Every single conflict effect has repercussions on food insecurity. Violence is likely to impact the planting season. In addition violence can have negative effects on the livestock migration. People will avoid crowded places dropping market attendance, effecting the livelihood of local farmers and herders. A banned but common practice of war is the hunger as weapon. Economic sanctions are commonly assigned to a well defined actor operating wrong actions.
- **People Security and Development Deterioration**: it is a long-lasting effect of lowering investments in health and education.

1.3.4 Conflict in Liptako-Gourma

Liptako-Gourma conflicts are not started as food riots. But raids on civilians are livelihood source for the attackers which steal livestock and goods. In Liptako-Gourma, conflicts are influenced by:

- **Competition for Land and Water**
- **Droughts, Floods and Climate Change**
- **Lack of Governmental and Local Stability**
- **Marginalization of Ex-Soldiers**: over the years it brought at the creation of extremist armed groups
- **Displacements**

Consequences of the Liptako-Gourma conflicts are atrocious for the civilians. An high number of IDPs each year has to leave their home and survive in a precarious situation. Food prices suffer and increase that leads a growing chunk of population into food insecurity. Food security is also threatened by impacts on agricultural planting season (between March and mid-May in Burkina-Faso) and on livestock migration (between January and June in Burkina-Faso). The economy of the afflicted and neighboring zones is impacted. Long-lasting effects today can be seen in each population who misses to bring education and basic service access at each single citizen.

2 Data

In order to assess the food insecurity-conflicts vicious cycle in Liptako-Gourma, an overview of the Open Data available has been made. We looked for sub-national level data, precisely administrative level 2. We called these administrations provinces.

We worked with data from 2014 to 2020. COVID 19 is excluded from the study. The pandemic data are updated more frequently than the data we considered. We worked with annual based data. Weather data are excluded from the study for the same reason.

We collected openly available secondary data, obtaining further experimental data through manipulation.

All the data has been last updated on August 2020.

2.1 Data Gathering

Food Security and Nutrition Working Group, West and Central Africa (FSNWG) updates the database of the framework Cadre Harmonise[17] (CH) every year. CH is a framework which synthesizes indicators of food and nutrition security outcomes at sub national level and represents implications for strategic response in food security and nutrition. It uses the framework Integrated Food Security Phase Classification (IPC) to classify different phases of food security.

The ACLED project[6] focuses on tracking a range of violent and non-violent actions by different agents. It collects data for the three countries we are interested in: Burkina Faso, Mali and Niger. Data contains specific information on location, type of action and number of fatalities.

There is no livestock price data openly available. This situation is a considerable deficiency. Livestock is crucial in the economy of Liptako-Gourma and shapes the food security-conflicts vicious cycle deeply. Livestock price data at sub-national level would have been remarkably suitable as a proxy for food security access and stability.

Cereal price data for Burkina Faso[19], Mali[20] and Niger[21], is gathered by World Food Programme (WFP), which guarantee weekly updates. Food prices from major markets are available especially for millet, corn, sorghum and rice. In this analysis we considered just the price of millet since this cereal is highly consumed in all the regions of Liptako-Gourma.

Internally Displaced People (IDPs) sub-national level data from 2014 to 2020 is available for Mali[12] and is published monthly by International Organization for Migration (IOM). IDPs data for Burkina Faso is available since 2020, while no open data regarding IDPs in Niger is accessible.

Data on Education, Gender, Health and Human Development could be useful to draw trends on food security and conflicts. This is available at national level for Mali, Burkina Faso and Niger, the countries studied in this research. We couldn't find any data on the listed arguments at sub national level, therefore we didn't integrated them.

2.2 Data Cleaning

Following the CH structure we organized the data so that it is possible to display it for each administrative level 2 and each year from 2014 to 2020. To be coherent some level 2 administrations have been renamed and/or aggregated.
To identify a query is given the following key:

`reference_year`: Year
`adm0_name` : Country
`adm1_name` : Region
`adm2_name` : Level 2 Administration (Provinces, Cercles, Departments)

The collected data has been synthesized into useful dimensions from the bibliographic research.

2.2.1 Cadre Harmonize

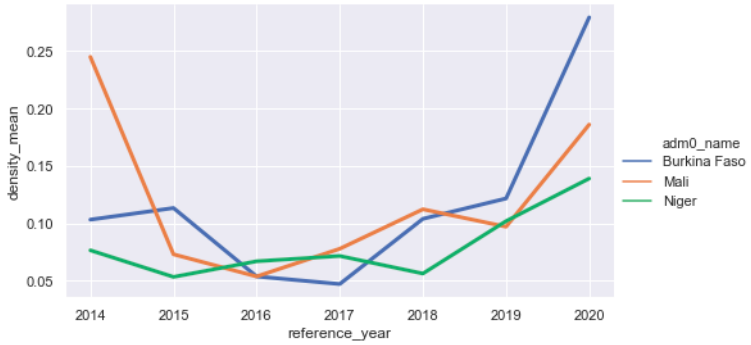

Figure 2.1: Percentage of food insecure people per country each year

`population` : Number of people who live in the province
`phase35` : Number of people in food insecure state
`p35_density` : Percentage of people in food insecure state

We used the variable `p35_density` as a proxy of food insecurity. This is a normalize float value between 0 and 1, where 0 stands for 0% of the population is in food insecure state, and 1 stands for 100% of the population is in food insecure state. We defined the food insecure state using the IPC Phase Class: people with an IPC of (1, 2) are considered in food secure state, people with an IPC of (3, 4, 5) are considered in food insecure state.

2.2.2 Millet Prices

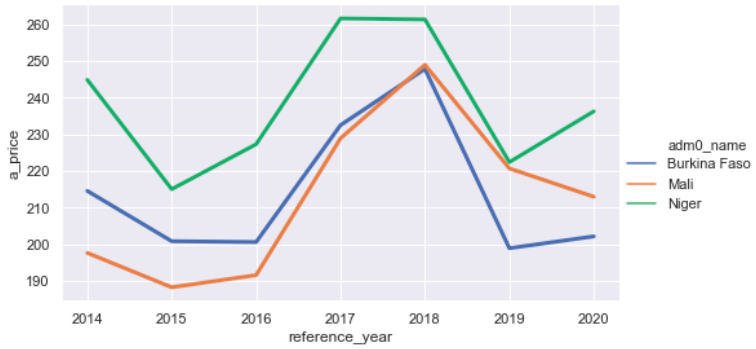

Figure 2.2: Average millet price per country each year (FCFA)

Figure 2.3: Average millet price variation per country each year (FCFA)

`actual_price` : Average price of millet in the current year
`decade_price` : Average price of millet during the decade
`diff_price` : Difference between current year average price and decade average price of millet
Millet Prices have been synthesized into two variables. The first is `actual_price` a positive float value. The second is `diff_price = abs(actual_price - decade_price)` a positive float value. To calculate `diff_price` we found the positive value of the subtraction between the actual year average price and the last decade average price. We choose to utilize the absolute value because we just want to understand if the price is changing and not if it is increased or decreased.

We used data on cereal prices. We choose millet as proxy for food prices for two reasons: it is one of the most accessible and consumed food in all Liptako-Gourma and it is the most widely represented data in the database. The other possibilities were corn, sorghum, rice (local and imported), beans and groundnuts. Not all these foods were represented with a sufficient number of entries to confidently assure a respectable result.

2.2.3 Violent Conflicts

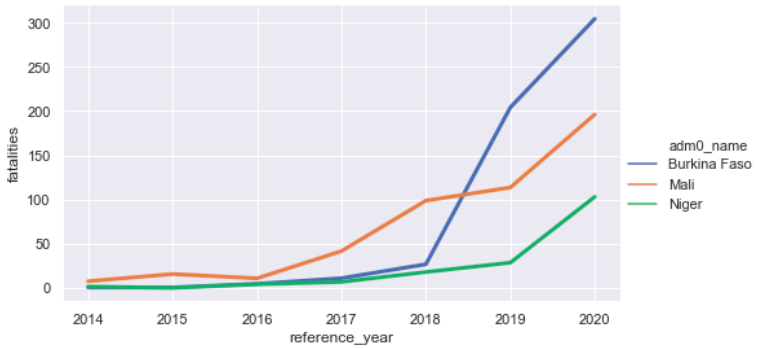

Figure 2.4: Violent conflicts fatalities per country each year

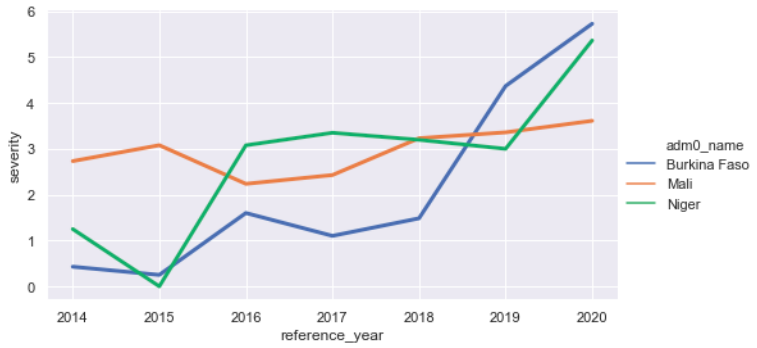

Figure 2.5: Violent conflict severity per country each year

`fatalities` : Number of fatalities
`conflicts` : Number of conflicts
`severity` : Fatalities divided by conflicts

To describe the outflow of conflicts in a certain area we selected two variables. The first is `fatalities` a positive or zero integer value, which indicates the size of conflicts. The second is `severity = fatalities / conflict` a positive or zero float value, which indicates the severity of the conflict.

We gathered conflicts data until July 2020. We projected the total 2020 conflicts and fatalities as `'the number of conflicts and fatalities until July 31, 2020' * 12 / 7` for each province.

2.2.4 Internally Displaced People

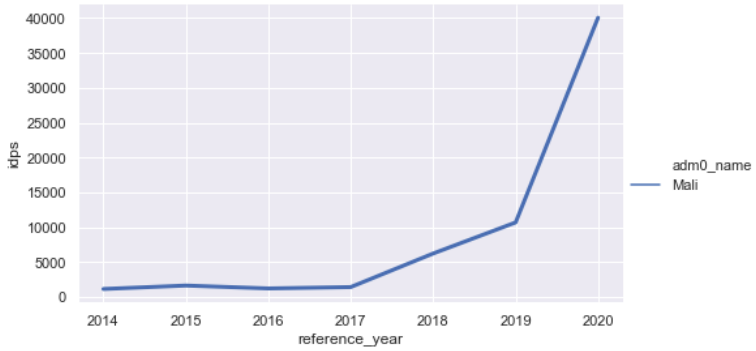

Figure 2.6: IDPs in Mali each year

`idps` : Total IDPs in the year
IDPs Data has been synthesized into one variable. The variable is `idps`, a positive or zero integer value.

IDPs data was available only for Mali from December 2014. We gathered data until April 2020. We projected the total 2020 IDPs as `'the number of IDPs until April 30, 2020' * 3` for each province in Mali.

3 Methodology

The data was cleaned and analysed writing Python programs and notebooks, using the libraries `numpy, scipy, pandas, matplotlib.pyplot` and `seaborn`.
We partitioned the Liptako-Gourma food insecurity-conflict vicious cycle into the following fields:

- **Food Insecurity** decribed by Percentage of Food Insecure People
  - Food Availability
  - **Food Access** decribed by Actual Food Prices
  - Food Utilization
  - **Food Stability** described by Food Prices Stability
- Conflict
  - **Conflict Size** described by Number of Fatalities
  - **Conflict Severity** described by Fatalities divided by Conflicts
- IDPs
  - **IDPs Size** described by Number of IDPs

We selected the fields in bold character as the six dimensions which represent the food insecurity-conflict vicious cycle.

The study main objective is to assess the food insecurity-conflicts vicious cycle of Liptako-Gourma in order to help the provinces which are more in need of first aid interventions.
To achieve it we set the following specific objectives:

- Identifying the three most afflicted provinces: the ones with higher percentage of food insecure people.
- Comparing the dimensions of the selected provinces and determining analogies and differences.
- Assessing evolution of the dimensions values over the years for the selected provinces and for all Liptako-Gourma.

The first specific objective is necessary to understand where humanitarian aid is needed. Then we want to know what is upsetting the security of the selected places. Furthermore it is possible to understand why these things happened through an historic dimensions analysis. Expanding the analysis in the surrounding region gives us less specific but more widespread information.
Firstly we studied the objectives with an empirical analysis on the three most afflicted provinces. Later we analysed the correlations between each dimension in the countries of Liptako-Gourma.

3.1 Empirical Analysis

In order to identify the 3 most food insecure provinces, we sorted all the provinces by the percentage of population in food insecure state in 2020. Then on the dimensions of the 3 more problematic provinces we asked the following questions:

- What resulted from the provinces dimensions in 2020 comparison?
- How did each province dimension evolve through the years since 2014?

To answer these questions we plotted graphs using `matplotlib.pyplot` and `seaborn` Python's libraries. Then we commented the data tables and plots.

3.1.1 Provinces Dimensions Comparison in 2020

	reference_year	adm0_name	adm1_name	adm2_name	p35_density	actual_price	diff_price	fatalities	severity	idps
0	2020	Burkina Faso	Sahel	Soum	0.44	223.14	6.07	783	6.64	NaN
1	2020	Mali	Gao	Menaka	0.41	261.09	10.00	33	1.22	62973.0
2	2020	Mali	Gao	Bourem	0.31	261.09	10.00	111	9.25	34422.0

Figure 3.1: Table most food insecure provinces dimensions in 2020

It's natural to think that food insecurity is positively correlated with both conflict's dimensions: size and severity. Actually sometimes conflict suffering might vary independently from food insecurity: both food insecurity and conflict suffering can be influenced by absent factors. This consideration helps to understand why these 6 dimensions are not always directly and strongly correlated. Indeed most of these dimensions should be positively correlated, but also they describe the same general concept from different points of view.

We highlighted the most influential factors that impact the food security for each province. This was done by looking at the three records table (in Figure 3.1) which prints out the dimensions of the most food insecure provinces in 2020.

The data describing IDPs Size was available only for Mali's provinces.

3.1.2 Provinces Dimensions Evolution since 2014

	reference_year	adm0_name	adm1_name	adm2_name	p35_density	actual_price	diff_price	fatalities	severity	idps
0	2020	Burkina Faso	Sahel	Soum	0.440	223.14	6.07	783	6.64	NaN
1	2020	Mali	Gao	Menaka	0.410	261.09	10.00	33	1.22	62973.0
2	2020	Mali	Gao	Bourem	0.310	261.09	10.00	111	9.25	34422.0
3	2019	Burkina Faso	Sahel	Soum	0.230	216.14	13.06	923	5.46	NaN
4	2019	Mali	Gao	Menaka	0.240	250.87	0.22	273	7.38	17758.0
5	2019	Mali	Gao	Bourem	0.210	250.87	0.22	5	0.45	10573.0
6	2018	Burkina Faso	Sahel	Soum	0.237	259.14	29.93	161	1.96	NaN
7	2018	Mali	Gao	Menaka	0.210	275.11	24.02	384	6.86	12543.0
8	2018	Mali	Gao	Bourem	0.210	275.11	24.02	28	2.15	6405.0
9	2017	Burkina Faso	Sahel	Soum	0.030	245.57	16.36	64	1.23	NaN
10	2017	Mali	Gao	Menaka	0.290	258.18	7.09	128	3.66	7291.0
11	2017	Mali	Gao	Bourem	0.250	258.18	7.09	18	1.38	3851.0
12	2016	Burkina Faso	Sahel	Soum	0.090	214.56	14.65	19	1.73	NaN
13	2016	Mali	Gao	Menaka	0.090	209.79	41.30	16	2.29	2064.0
14	2016	Mali	Gao	Bourem	0.100	209.79	41.30	2	2.00	3679.0
15	2015	Burkina Faso	Sahel	Soum	0.360	214.69	14.52	2	1.00	NaN
16	2015	Mali	Gao	Menaka	0.050	204.82	46.27	27	2.45	2659.0
17	2015	Mali	Gao	Bourem	0.270	204.82	46.27	22	2.75	2206.0
18	2014	Burkina Faso	Sahel	Soum	0.200	230.93	1.72	0	0.00	NaN
19	2014	Mali	Gao	Menaka	0.400	211.68	39.41	7	1.75	2079.0
20	2014	Mali	Gao	Bourem	0.450	211.68	39.41	13	1.62	1484.0

Figure 3.2: Table most food insecure provinces dimensions since 2014

In the 3 most afflicted provinces we studied the evolution of each dimension.

Confronting the graphs in Figure 4.7 we analysed the trends of each different dimension.

The variable the study is centered around is `p35_density` (food insecurity). In this variable we looked for changes reflecting other variables patterns. Local minimum and maximum spikes of `actual_price` (food prices) tell us when something has changed in the local economy. When inflation continues to grow people's food access decreases. The more `diff_price` (food price stability) is far from zero the more instability will characterize the province. A safe province has near zero `fatalities` (conflict size). Between conflict prone provinces the ones with higher `severity` (conflict

severity) have deadlier conflicts. Provinces with an high number of `idps` (IDPs) are prone to lose food availability, stability and access. On top of that they have an higher risk of igniting new conflicts from confrontations and collisions.

Particular patterns found in this empirical analysis have been utilize to better guide the subsequent generalized analysis of the region.

3.2 Correlation

		p35_density	actual_price	diff_price	fatalities	severity
reference_year	adm0_name					
2016	Burkina Faso	0.06	200.59	14.09	4.57	0.71
	Mali	0.06	191.56	27.25	10.73	1.72
	Niger	0.08	227.28	13.26	4.00	3.45
2017	Burkina Faso	0.06	232.49	17.81	10.86	0.73
	Mali	0.10	228.90	10.08	41.60	2.25
	Niger	0.09	261.61	21.07	6.70	3.04
2018	Burkina Faso	0.11	247.84	33.16	26.71	0.73
	Mali	0.11	248.96	30.15	98.67	3.01
	Niger	0.07	261.34	20.80	17.90	2.04
2019	Burkina Faso	0.14	198.90	15.77	204.14	3.73
	Mali	0.11	220.68	1.98	113.53	2.59
	Niger	0.14	222.39	18.15	28.50	2.98
2020	Burkina Faso	0.28	202.14	12.54	304.43	4.96
	Mali	0.20	212.95	11.20	196.20	3.99
	Niger	0.15	236.27	6.65	103.00	3.99

Figure 3.3: Table evolution countries dimensions 2016-2020

We studied the correlation between the dimensions in a wider context than the single provinces. We studied and plotted the correlations for the group of provinces considered in the study although divided in their national borders.

In order to simplify the vocabulary we used the names of the countries to identify only those country provinces contemplated in the study, so respectively Burkina Faso, Mali and Niger.

From the plotted graphs 2.1, 2.2, 2.3, 2.4, 2.5, 2.6 in Section 2.2 Data Cleaning, we noticed that `p35_density` values in 2014 and 2015 seems uncorrelated with the other dimensions. This is particularly true in Mali. Therefore we studied the dimension's correlation only on the data from 2016 to 2020.

The correlation highlighted which dimensions are linked stronger and which describe a more isolate corner of the food insecurity-conflict vicious cycle.

Two correlated dimensions in Liptako-Gourma are certainly interesting descriptors of the general situation. These dimensions and their relationship should be understood and studied deeply when providing humanitarian assistance in the region.

4 Results

4.1 Empirical Analysis

Taken all the 2020 data, we sorted the provinces for `p35_density`. The three provinces with higher percentage of people in food insecure state are: Soum (Burkina Faso), Menaka and Bourem (Mali).

4.1.1 Provinces Dimensions Comparison in 2020

We compared each dimension of the three most problematic provinces as shown in Table 3.1.1.

In the food insecurity field the provinces showed the following characteristics: Soum was the province with higher percentage of people in food insecure state, followed by Menaka and Bourem. Menaka and Bourem provinces belonging to the same region (Gao), have the same average millet price (food access). The same is also true for the difference between the average millet price and the average decade millet price (food stability). The average price of millet per kilogram was 261.09 FCFA ($ 0.47) in the region of Gao (Menaka, Bourem) while it was 223.14 FCFA ($ 0.41) in the region of Sahel (Soum). Furthermore the instability of millet price was slightly larger in Gao than in Sahel regions.

In the conflict field we observed that Soum province was way more stormed rather than the 2 Mali's provinces. In Soum 783 people died. Bourem was also afflicted with 111 fatalities, and it suffered way fewer conflicts through the year. In fact the severity of Bourem conflicts exceeded 9 fatalities per conflict. Soum's severity was 6.64 while Menaka, with 33 total fatalities and a severity of 1.22, had a modest number of conflicts characterized by fewer cruelty.

Menaka was majorly exposed in the IDPs dimension. With almost 63 thousand internally displaced people in the province, Menaka was really strained. In Bourem instead there were 34422 IDPs in 2020. Burkina Faso and Niger IDPs data are not in the database.

4.1.2 Provinces Dimensions Evolution since 2014

The first dimension we studied the evolution about is food security. 2014 and 2015 data, for the 3 provinces considered, already showed an high value in the percentage of people in food insecure state. This is the effect of 2012-2013 malian crisis which in 2014 and 2015 was sedated in some provinces, with close to zero conflicts and IDPs. In the same years it provoked an extremely high food insecurity in Mali first and neighboring countries later. In Mali the average price of millet was significantly lower than the average of the decade in the years from 2014 to 2016.

The situation evolved since 2016: conflicts and IDPs both grew together with food insecure people. It's safe to assume that Bourem through the years has been the safer of the considered provinces. Even though the conflict size is grown in this province in 2020. For both Bourem and Soum we can say that food insecurity expanded alongside conflict size and severity since 2016. In Menaka it was true until 2020 when food insecurity continued to rise and conflict stopped almost entirely. This could be explained by an increment in conflicts in the bordering regions, Tillabery and Tahoua of Niger and Gao in Mali. If the supposition is true it demonstrates a displacement of the armed groups who wandered in the province.

In the considered provinces of Mali IDPs saw a exponential increment each year since 2016, when the firsts conflicts post malian crisis started. This growth was also side by side with the food insecurity one.

It is useful to notice that in the Figure 4.2 and 4.3 the Menaka price evolution cannot be seen because it coincides with the Bourem's one as they both belong to the same region, Gao. In Figure 4.6 Soum's IDPs evolution is not drawn as there is no IDPs data gathered for Burkina Faso and Niger.

Figure 4.1: Percentage of food insecure people in most food insecure provinces through the years

Figure 4.2: Average millet price in most food insecure provinces through the years

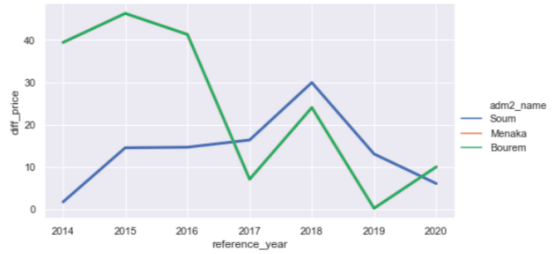

Figure 4.3: Average millet price variation in most food insecure provinces through the years

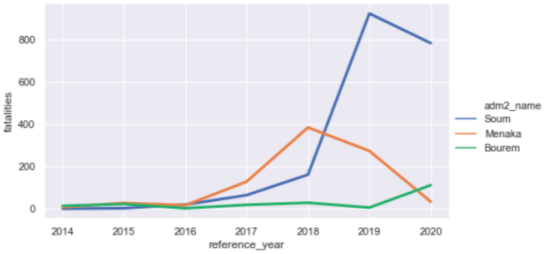

Figure 4.4: Violent conflicts fatalities in most food insecure provinces through the years

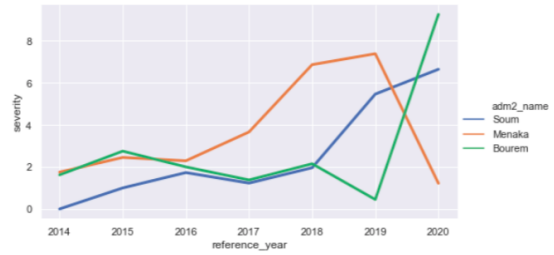

Figure 4.5: Violent conflict severity in most food insecure provinces through the years

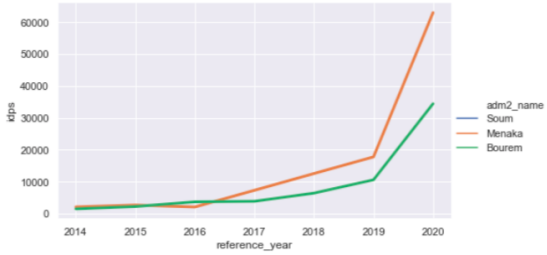

Figure 4.6: IDPs in most food insecure provinces through the years

Figure 4.7: Empirical evolution analysis since 2014

4.2 Correlation: Countries Dimensions Evolution since 2016

We studied the correlation between the different dimensions describing the food insecurity-conflict vicious cycle. The following findings allowed us to infer the accuracy of the dimensions supposition.

We analysed the correlation of each country separately: Burkina Faso, Niger, Mali. Then we studied the correlation of the entirety of Liptako-Gourma. All the analysis done in this Section 4.2, used the data from 2016 to 2020. The main reason of this choice was the awareness noticed in both the Data Cleaning 2.2 and the Empirical Analysis 3.1.2 Sections. The dimension describing food insecurity seemed to be better described particularly by Conflict and IDPs dimensions in the 2016-2020 interval.

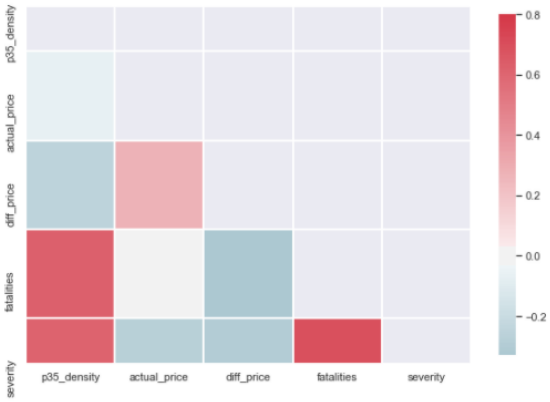

Figure 4.8: Graph Burkina Faso Correlation

	p35_density	actual_price	diff_price	fatalities	severity
p35_density	1.000	-0.062	-0.251	0.627	0.614
actual_price	-0.062	1.000	0.277	-0.022	-0.275
diff_price	-0.251	0.277	1.000	-0.330	-0.292
fatalities	0.627	-0.022	-0.330	1.000	0.694
severity	0.614	-0.275	-0.292	0.694	1.000

Figure 4.9: Table Burkina Faso Correlation

Figure 4.10: Burkina Faso Correlation Analysis 2016-2020

From the Burkina Faso correlation table we spotted a strong link between the conflict field and the dimension of food insecurity described by the percentage of people in food insecure state. Both the dimensions of conflicts correlate with the food insecurity dimension with a factor larger than 0.6. Conflict size and conflict severity also correlate each other with a shy 0.7 factor which suggests that zones with high conflict size are also described by murderous conflicts.

Instead the millet prices did not represent the food insecurity dimensions of access and stability in Burkina Faso. Both the correlation factors between food prices and food insecurity are negative. While the food stability dimension has a solidly negative correlation, the millet price correlation value is almost in no man's land. It suggests that millet prices in Burkina Faso have an independent relationship with food security. The intersection between millet price and its variation with the conflict related dimensions have constantly negative values.

It is possible to read all correlation values in Table 4.9.

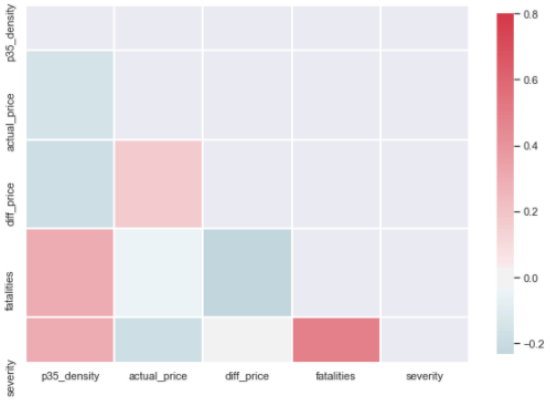

Figure 4.11: Graph Niger Correlation

	p35_density	actual_price	diff_price	fatalities	severity
p35_density	1.000	-0.151	-0.177	0.305	0.305
actual_price	-0.151	1.000	0.164	-0.046	-0.177
diff_price	-0.177	0.164	1.000	-0.234	-0.004
fatalities	0.305	-0.046	-0.234	1.000	0.490
severity	0.305	-0.177	-0.004	0.490	1.000

Figure 4.12: Table Niger Correlation

Figure 4.13: Niger Correlation Analysis 2016-2020

The Niger situation is extremely similar to the situation of Burkina Faso. All the correlations are slightly weaker but all of them respect the sign given in the correlation analysis in Figure 4.10.

The conflict size and conflict severity dimensions were both correlated positively with food insecurity by a factor of 0.3, the half of Burkina Faso's ones. The weaker correlation could be explained by the presence of the Tahoua region. This region is almost entirely semi-desert. In this region conflicts are occasional given the lack of strategic targets.

All the correlation values are shown in the Table 4.12.

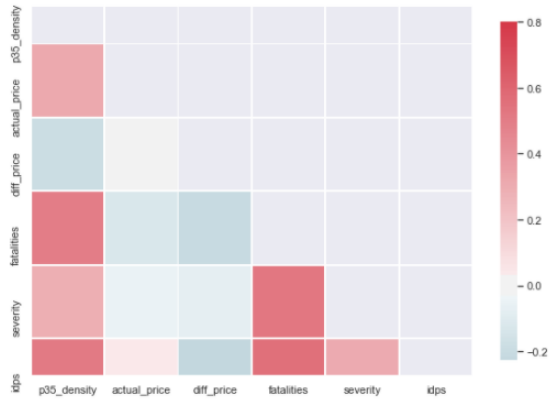

Figure 4.14: Graph Mali Correlation

	p35_density	actual_price	diff_price	fatalities	severity	idps
p35_density	1.000	0.317	-0.184	0.506	0.293	0.516
actual_price	0.317	1.000	-0.026	-0.124	-0.049	0.038
diff_price	-0.184	-0.026	1.000	-0.207	-0.076	-0.228
fatalities	0.506	-0.124	-0.207	1.000	0.527	0.560
severity	0.293	-0.049	-0.076	0.527	1.000	0.309
idps	0.516	0.038	-0.228	0.560	0.309	1.000

Figure 4.15: Table Mali Correlation

Figure 4.16: Mali Correlation Analysis 2016-2020

The Mali correlation graph is more interesting given the presence of IDPs and the food price curious position. Conflict size and conflict severity both correlate positively to the food insecurity dimension with respective factors of 0.51 and 0.29. While the food stability dimension shows the usual slightly negative correlation we are used to, in Mali the food access dimension is exotic. Here the millet price positively correlates with the food insecurity dimension for a factor bigger than 0.3.

The IDPs dimension correlates positively with conflict size (0.56) and conflict severity (0.31). Food access dimension shows independence from IDPs dimension, while the chosen food stability dimension is slightly negative correlated. The correlation value between the food insecurity dimension and IDPs size dimension of 0.52 describes a solid positive correlation. This is a further attestation of the strong link between IDPs and food insecurity-conflict vicious cycle. The IDPs dimension is independent from the food access dimension and slightly negative correlated with the food stability dimension.

All the correlations are reported in the Table 4.15.

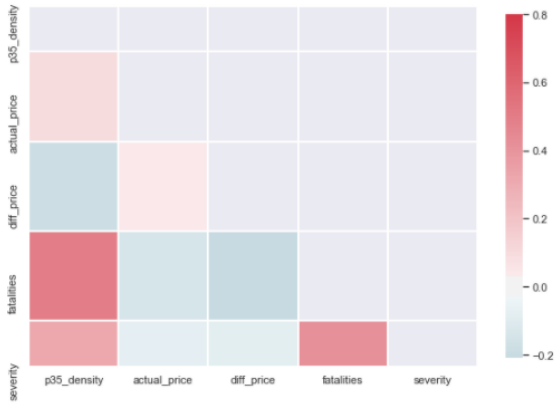

Figure 4.17: Graph Liptako-Gourma Correlation

	p35_density	actual_price	diff_price	fatalities	severity
p35_density	1.000	0.095	-0.186	0.498	0.324
actual_price	0.095	1.000	0.045	-0.141	-0.077
diff_price	-0.186	0.045	1.000	-0.210	-0.080
fatalities	0.498	-0.141	-0.210	1.000	0.414
severity	0.324	-0.077	-0.080	0.414	1.000

Figure 4.18: Table Liptako-Gourma Correlation

Figure 4.19: Liptako-Gourma Correlation Analysis 2016-2020

Analysing all the countries together we obtained the relationships between the dimensions in the totality of Liptako-Gourma. The strongest correlation is given by conflict size and food insecurity dimension with a 0.50 factor. Conflict severity and food insecurity are also positively correlated with a 0.32 factor. A correlation factor of 0.41 describes the conflict field correlation between size and severity.

Millet price and millet price stability are both independent from all the other dimensions (food security, conflict size and conflict stability).

All the IDPs correlations reflect the ones we obtained in Mali. IDPs dimension and conflict size and severity are strongly correlated. IDPs field was independent from food access and slightly negative correlated with food stability. Food insecurity correlates solidly with IDPs.

5 Summary and Recommendations

In this paper we studied how conflict and food security affect each other in a vicious cycle in the provinces of Liptako-Gourma. By comparing the percentage of people in food insecure state in the 2014-2020 period with conflict and IDPs related dimensions we were able to highlight their relationships and correlation. We find that the food insecurity dimension is strongly correlated with conflict size and severity. Furthermore food insecurity grew side by side with IDPs in Mali.

Most people usually starve because of lack of food access rather than availability. It is not enough to limit the description of the access pillar at a single weak variable. In future researches to describe the access dimension of food security an array of variables should be utilized. Surely livestock price data is necessary to comprehend the Liptako-Gourma food security evolution. But also the price of other relevant cereals (sorghum, rice, corn) consumed in the area and every food staple consume in high quantity. Income and how it is distributed should be considered in a future analysis.

The difference between food prices from the average food prices in the decade does not represent the stability pillar of food security. A different idea which could better describe the food stability dimension is given by the price growth: difference between the actual price of an asset and the last year price of that asset. Price growth differs strongly from what we called price stability in two situations: two consecutive years with similar price which is far from the decade average will have a close to zero price growth; last year price far from decade average price and this year price near the decade average price will have an high price growth and a small price stability. The price growth dimension is a better descriptor of the food stability because it catches the price variation year per year.

On the IDPs data we worked only with Mali's one. Burkina Faso IDPs data is available since 2020 in the IOM database. Niger IDPs data is not available. Seen the high correlation between IDPs, conflict and food security it's interesting to enlarge the analysis to Niger and Burkina Faso too. The expansion of the IOM database to all the Liptako-Gourma region is needed.

In Liptako-Gourma multiple diseases influence the health of humans, animals and plants. Other than COVID-19, that spread and hit the entire world, others epidemic are common. Mosquitoes are the animal that kill the most humans in the world through malaria. Not vaccinated livestock are endangered by plagues, infections and fevers. Fall armyworms and locusts are an enormous threat to the harvest. All these diseases affect the food security of the population. We didn't considered them in the analysis but they could be correlated hidden variables.

The continuous deterioration of the climate in the world is felt particularly in Liptako-Gourma, a semi-desert landlocked zone. Droughts are ordinary and floods ravage the fields and the cities during the rainy season (June-October in Liptako-Gourma).

Is necessary to differentiate first aid help from long term population needs. While the first is just the fulfillment of survival necessities, the second is the basis of life. Education itself is the most important need because in the long term it will guarantee the others directly from the people: stability and safety. Always these three needs have to be assured by the government because each one is conditioned by the existence of the others. Capturing these dimensions can be really interesting, but to measure them and their effects longer periods need to get analysed.

In order to be helpful in humanitarian aid plan, all the possible dimension cited should have open data available to everyone that describe accurately that dimension.

This work had the object of demonstrate the food security and conflict correlation. From the open data analysed we can conclude that the food security-conflict vicious cycle that is hampering the region of Liptako-Gourma, feeds himself and external effort is needed. The plan of humanitarian intervention with the intent of strengthening the resilience of the region is crucial to break the vicious cycle of food security and conflict.

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