

Abstract

Climate change in Africa's Sahel region is significantly impacting agriculture and land use, human settlements, traditional migration patterns, and access to resources and markets. In the western Sahel region, recent migration trends have brought pastoralists into lands occupied by sedentary farmers, resulting in a major source of high-risk conflict areas in the region. Our project, Data Analytics for Sahelian Herders (DASH), aims to map and analyze the changes in migration patterns, seasonality, and urban and agricultural development using data from satellites, mobile telecommunications, and GPS-enabled systems. DASH will produce a near real-time forecasting model using big data analytics and artificial intelligence (AI) techniques to anticipate areas of potential violent conflict between farmers and pastoralists in the Sahel, which can be utilized to design effective and relevant policies on local, national, and regional levels. DASH will enable decision-makers to anticipate the effects of climate change and be best-prepared to mitigate its negative effects. Our project directly supports the identified targets of the following Sustainable Development Goals (SDGs): No Poverty; Sustainable Cities and Communities; Climate Action; Peace, Justice, and Strong Institutions; Life on Land, and Partnerships for the Goals.

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GENEVA CHALLENGE 2018

DASH

Data Analytics for
Sustainable Herding

A photograph of a man herding cows in a dry, open landscape. The man is wearing a blue jacket, orange shorts, and a red and yellow patterned hat. He is holding a wooden staff. The cows are in the foreground, and the background shows a dry, hilly landscape under a clear sky.

Using Big Data and Artificial Intelligence to
prevent climate-driven violent conflict in the Sahel

Jessica Arnold - Alonso Flores - Nigora Isamiddinova - Qi Ji - Nitasha Nair

Columbia University

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DASH

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Sustainable Herding

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EXECUTIVE SUMMARY

Africa's Sahel region is the semi-arid belt south of the Sahara Desert stretching from Senegal to Chad, where pastoralism and agriculture contribute to almost 90% of the economy. Increasing climate variability in the Sahel and the resulting onset of negative shocks, in conjunction with economic vulnerability, and social and political marginalization, are significantly impacting the ability of the Sahelian pastoralists to cope with these changes. The traditional coping mechanism - transhumance and migration - is becoming increasingly associated with conflict and additional stresses as the pressure and competition for limited resources, such as land and water, grows between pastoralists and farmers.

In the western Sahel region, changing rainfall patterns are driving a southward migration of pastoralists into lands occupied by sedentary farmers, resulting in a major source of violent conflicts. In conjunction with other sources of instability, these conflicts have, in part, contributed to the deterioration of farmlands and cattle industry, with adverse implications for food and human security and economic growth, leading to further destabilization of an already fragile region.

While historically serving as one of West Africa's politically stable anchors, Senegal represents, at a country-level, many of the trends that the Sahel is experiencing, including an uptick in migration, resource shortages, and high-risk areas. The understanding of and response to seasonal migration by authorities is constrained by the lack of reliable aggregated information and a clear comprehension of how various factors interact to affect pastoralists' livelihoods. Fortunately, increasing availability and access to quality data through new data streams such as anonymized mobile phone call detail records (CDRs) and high-resolution Earth Observation (EO) data combined with climate information offer a new opportunity to enable rapid, large-scale measures of populations and movements.

Our project, Data Analytics for Sustainable Herding (DASH), aims to map and analyze the spatial and temporal changes in migration patterns, seasonality, and urban and agricultural development using data from government statistics, EO satellites, mobile and GPS-enabled systems. DASH seeks to map the current zones of conflicts and to develop a near real-time forecasting model to identify resource constraints and potential areas of violent conflict through the application of big data analytics and artificial intelligence (AI). DASH aims to create a blueprint for using big data and AI for better policy and decision-making under deep uncertainty. Our model will provide location and time-specific information and insights that could be leveraged to design truly sustainable and contextually relevant solutions and policies for climate adaptation and conflict prevention.

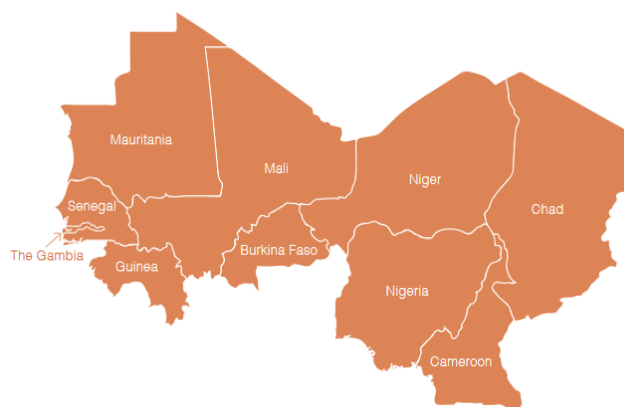
1. INTRODUCTION AND PROJECT SCOPE

The 2030 Agenda for Sustainable Development and the Paris Agreement both recognize climate change as one of the greatest challenges of our time, while underscoring the intrinsic, mutually reinforcing importance of climate action, sustainable development and poverty reduction. Our project aims to serve as a comprehensive solution to these challenges, while also addressing the issue of violent conflict prevention.

1.1 CLIMATE CHANGE IN THE SAHEL

Africa's Sahel region is a semi-arid belt south of the Sahara, which includes 10 countries, stretching from Senegal to Chad (see Figure 1). The Sahel experiences recurring extreme weather patterns such as floods and droughts, which have lasted decades, impacting the crops and livelihoods of an estimated 100 million people.¹²

FIGURE 1: THE SAHEL REGION BOUNDARIES ACCORDING TO THE UN DEFINITION.



The climate models project that the larger West African Sahel region will experience an increase in the average temperatures by 3-6°C, increase in the interannual variability of rainfall and an increase of extreme weather events, such as erratic rainfall, droughts, floods and thunderstorms.³ Although the current climate change impact prediction models possess a high degree of uncertainty on a local scale, climate variability is expected to further increase with a higher frequency of extreme weather events.⁴⁵⁶ This variability is further exacerbated by degrading land conditions, quickly growing populations, and

¹ Al Jazeera, "Analysis: Understanding the Sahel Drought", 2012, <https://goo.gl/yZnxc3>.

² United Nations, "UN Support Plan for the Sahel," 2018, <https://goo.gl/6M9VpT>.

³ "Climate Change Risk in West Africa Sahel: Regional Factsheet." 2017. USAID.

⁴ Tor A Benjaminsen et al., "Does Climate Change Drive Land-Use Conflicts in the Sahel?" *Journal of Peace Research* 49, no. 1 (January 1, 2012): 97–111, <https://doi.org/10.1177/0022343311427343>.

⁵ Giannini, Alessandra, Michela Biasutti, Isaac M. Held, and Adam H. Sobel. 2008. "A Global Perspective on African Climate." *Climatic Change* 90 (4): 359–83. <https://doi.org/10.1007/s10584-008-9396-y>.

⁶ (Adger and Vincent 2005, IPCC 2007)

widespread poverty. Livelihoods in the Sahel are disproportionately affected by environmental shocks and contribute to upticks in conflict, resulting in a burgeoning displacement crisis across the Sahel.⁷

Over 54.4 million people in West African Sahel alone could be forced to move if no action is taken to counter the rate of climate change or its negative impacts in a business-as-usual scenario, thus creating a category of internal climate migrants or climate refugees.⁸ ⁹“*Embedding climate migration into development planning*” and “*investing now to improve understanding of internal climate migration*” are two of the four urgent actions from the Groundswell report on climate-induced migration.

Given the high uncertainty of the climate projections and the urgency to act, it is crucial to understand the extent to which migration routes have been affected and how rainfall patterns and seasonal shifts have contributed to these changes. Additionally, it is necessary to develop tools to monitor and evaluate the current climate and migration patterns to be able to effectively design and adopt relevant policies, as well as allocate resources to increase the resilience of the most vulnerable populations.

1.2 PASTORALISM IN THE SAHEL

Pastoralism is a major economic activity in the Sahelian countries. It provides direct livelihoods to 25-41 million people and represents a significant share of income for 72-94 million people in the Sahel and Horn of Africa. In the Sahel, livestock trade contributes between 10-20% of the region’s GDP.¹⁰ Its importance was further highlighted at the recent UN Security Council where it was pointed out that 90% of the Sahel’s economy relies on agriculture and pastoralism, making it vulnerable to any extreme event.¹¹

Although, historically, the pastoralist population in the region has been one of the most resilient when it comes to adapting to harsh climate and environmental conditions, through transhumance and migration, today they are becoming more vulnerable due to various external shocks. Some of the factors that contribute to their livelihoods being more vulnerable are extreme weather, harsh climate conditions, land degradation, rapidly growing population, volatile nature of the pastoral economy, and poor health of livestock.

1.3 BENEFITS OF PASTORALISM FOR PEOPLE, PROSPERITY, PEACE, AND THE PLANET

One key challenge around pastoralism is the societal prejudice in support of the idea that pastoralism is unviable. Pastoral livelihoods are portrayed as being unproductive and environmentally destructive,

⁷ United Nations Office for the Coordination of Humanitarian Affairs (OCHA), “The Sahel,” 2016, <https://goo.gl/s2EEBm>.

⁸ Missirian, Anouch, and Wolfram Schlenker. 2017. “Asylum Applications Respond to Temperature Fluctuations.” *Science* 358 (December): 1610–14. <https://doi.org/10.1126/science.aao0432>.

⁹ Kumari Rigaud et al. 2018. *Groundswell: Preparing for Internal Climate Migration*. Washington, DC: The World Bank.

¹⁰ Haan, Cornelis de, ed. 2016. *Prospects for Livestock-Based Livelihoods in Africa’s Drylands*. The World Bank. <https://tinyurl.com/y7a7g2t4>

¹¹ UN Security Council, “UN Security Council: Climate-Related Security Risks,” 2018, <https://tinyurl.com/y9w58dsc>.

which induces authorities to encourage pastoralists to settle.¹² Nevertheless, more than two decades of research has provided evidence for the opposite: pastoralism is economically rational, viable and is a vital tool for large-scale conservation and ecosystem management.¹³ Working to increase the adaptive capacity of pastoralists to external shocks directly impacts upon four of the 2030 Agenda priority areas: people, prosperity, peace and the planet.

BENEFITS FOR PEOPLE

Studies have shown that livestock provides more food security than growing crops in many arid and semiarid areas, as nomadic pastoralism has better adaptive capacities than farming in arid environments such as the Sahel.¹⁴ By supplying both domestic and export markets, pastoralism can provide growing urban populations with competitively-priced meat. Pastoralism secures livelihoods not only for millions of producers, but also for tens of thousands of people working in and around the livestock trade.¹⁵

BENEFITS FOR PROSPERITY

Pastoral production has been shown to be more cost-effective and productive than the meat-focused ranching models that have been promoted in their place, with the potential to supply lower-cost products into markets. Research has demonstrated that pastoralism is 2 to 10 times more productive than commercial ranching under the same conditions when it comes to direct products.¹⁶ In addition, trade between pastoral communities in Africa generates an estimated 1 billion USD each year.¹⁷

BENEFITS FOR PEACE

The decades-long violent conflict between pastoralists and farmers in the Sahel has devastated local communities, drastically reducing both security and economic activity.¹⁸ However, pastoralism has been generally characterized by peace, owing to the strong traditions of cooperation and resource sharing amongst their communities,¹⁹ and mutually beneficial relationships with farmers.²⁰ The rise and prevalence of current conflicts are usually accompanied by underlying factors such as the erosion of local governance arrangements, expropriation of natural resources or alienation from services and community decision-making opportunities.²¹

¹² UNEP. n.d. "Sustainable Pastoralism and the Post 2015 Agenda". Nairobi, Kenya: UNEP. <https://goo.gl/vZ42Mi>

¹³ Ibid.

¹⁴ Krätli, Saverio & Hülsebusch, Christian & Brooks, S & Kaufmann, Brigitte. 2012. "Pastoralism: A critical asset for food security under global climate change". *Animal Frontiers*. 3. 42-50.

¹⁵ Idem

¹⁶ Hatfield and Davies. 2016. "Global Review of the Economics of Pastoralism". Nairobi, IUCN. <https://goo.gl/KXuK7M>

¹⁷ "Pastoralism's economic contributions are significant but overlooked". *IRIN*, May 16, 2013. <https://goo.gl/5Cx7sD>

¹⁸ Mercy Corps. n.d. "The Economic Costs of Conflict and the Benefits of Peace". Oregon. <https://goo.gl/8N8nFc>

¹⁹ Davies, J., Ouedraogo, R, Hagelberg, N. and M. Niamir-Fuller. 2015. "Sustainable Pastoralism for the Post 2015 Agenda". Brief for GSDR. <https://goo.gl/s1dPtz>

²⁰ "Pastoralism platform promotes peace in conflict-prone Central African Republic". *FAO*, September 12, 2016. <https://goo.gl/WtdpBt>

²¹ Davies, J., Ouedraogo, R, Hagelberg, N. and M. Niamir-Fuller. 2015. "Sustainable Pastoralism for the Post 2015 Agenda". Brief for GSDR. <https://goo.gl/s1dPtz>


BENEFITS FOR THE PLANET

Pastoralism can support a global transition towards a green economy, as sustainable pastoralism on rangeland ecosystems, such as desert grasslands, woodlands, and steppes, maintains soil fertility and contributes to water regulation and biodiversity conservation.²² While up to 70% of dryland soil carbon can be lost through conversion to agricultural use, there is evidence that animal grazing promotes the biodiversity and biomass production needed to maintain these carbon stores. As much as 409 million tons of CO₂, or around 9.8% of anthropogenic carbon emissions could be sequestered by improved grazing management.²³

1.4. PROJECT SCOPE

We chose Senegal as the pilot country for our project for three main reasons. First, Senegal enjoys relative political stability compared to its neighboring countries; second, Senegal is also home to a substantial pastoralist population - mostly Fulani, Fulbe (or *Peul* in French) and Serer ethnic groups; finally, Senegal has fewer inter-ethnic or religion-based conflicts than its neighbors. This allows to eliminate potentially confounding variables and set forth a clearer study of the pastoralist-farmer conflict. Senegal exhibits the many of the trends that the Sahel is experiencing, such as an uptick in migration, resource shortages, and high-risk areas. However, it also has unique characteristics that differentiate it from the rest of the Sahel, such as an increased climate variability and that close to 50% of the population is urban. The climate models project that the region will experience an increase in the number of hot days and that the average temperature will increase by an average of 3°C by 2050 with the rainfall becoming scarcer but more intense and less predictable in Senegal.²⁴²⁵ The project pilot will test the solution that aims to be replicable in other Sahelian countries, and be scalable to other pastoralist regions in the continent.

The Republic of Senegal



- Classified as a Least Developed Country (LDC) with a **GDP per capita of US \$2,600**
- **Population:** 14 million (46% living in urban areas)
- **Poverty rate:** 38% (2010)
- **Gini coefficient:** 40.3 (2011)
- Ranked 162 out of 170 untries in human development with an **HDI of 0.494**
- **Population with access to electricity:** 51.9%
- Agriculture, including livestock, contributes **15% to the GDP** and employs **77% of the workforce**.
- The livestock sector in Senegal is a traditionally extensive system. Livestock production is substantial, however, the country is dependent on imports to meet the growing national demand.
- Within pastoralist and agro-pastoralist households that depend on livestock, 37% are at the bottom income quintile and **more than 60% are considered poor or very poor**.

²² McGahey, D., Davies, J., Hagelberg, N., and Ouedraogo, R., 2014. "Pastoralism and the Green Economy – a natural nexus?" Nairobi: IUCN and UNEP.

²³ Ibid.

²⁴ "Senegal Factsheet: Climate Information and Agricultural Planning." n.d. Accessed August 19, 2018. <https://tinyurl.com/y8nuf64l>.

²⁵ "Climate Change Risk in Senegal: Country Risk Profile." 2017. USAID.

2. THE PROBLEM: CONFLICT CAUSES AND DRIVERS

2.1 CONFLICT CONTEXT

Conflicts between farmers and pastoralists in the Sahel frequently revolve around issues of disputed land use and access to water. Often times, these conflicts are initiated or exacerbated by climate-induced movements of pastoralists. These conflicts have historically been local, sporadic, and low intensity without the direct involvement of governments and their security forces. However, within the past few decades, conflicts have continued to escalate both in terms of scale and degree of violence, as a result of a variety of factors, which include climate change, economic, social, and political circumstances.²⁶

Since its independence in 1960, Senegal has been the only West African country that has never been seized by military coup and has been a model for democracy and regional stability. However, violent conflicts still persist among pastoralists and farmers.²⁷ In the past decade, armed conflict, violent crimes, and terrorism have necessitated the use of alternative pastoral routes. In addition, climate-induced shocks have decimated pastoral grazing lands and caused pastoralists to expand their geographic radius to find adequate pasture and water. Additionally, agricultural land expansion has contributed to a loss of land for grazing. The aforementioned circumstances have led to increased cross-border transhumance, the seasonal movement of livestock from one grazing region to another, which increases the pressure on croplands and heightens the risk of violent conflicts.²⁸

2.2 CONFLICT AND CLIMATE CHANGE AS A THREAT MULTIPLIER

While climate change is not a direct cause of conflict, it is a significant contributing factor to heightened migration and violent conflict, as it minimizes the amount of available resources and increases competition. The impacts of climate change in the Sahel have, in part, contributed to an increase of violent conflict in the region, particularly related to conflicts between pastoralists and farmers. In 1989, a violent conflict that began along the Senegal River Valley resulted in an uproar of violence that spread as far as Dakar and Nouakchott, led to thousands of deaths, and impacted livelihoods of over a quarter of a million people.²⁹ While this particular conflict between Mauritania and Senegal was rooted in a local context, its impacts, similar to other farmer-pastoralist conflicts in the region, were palpable across the western Sahel region.

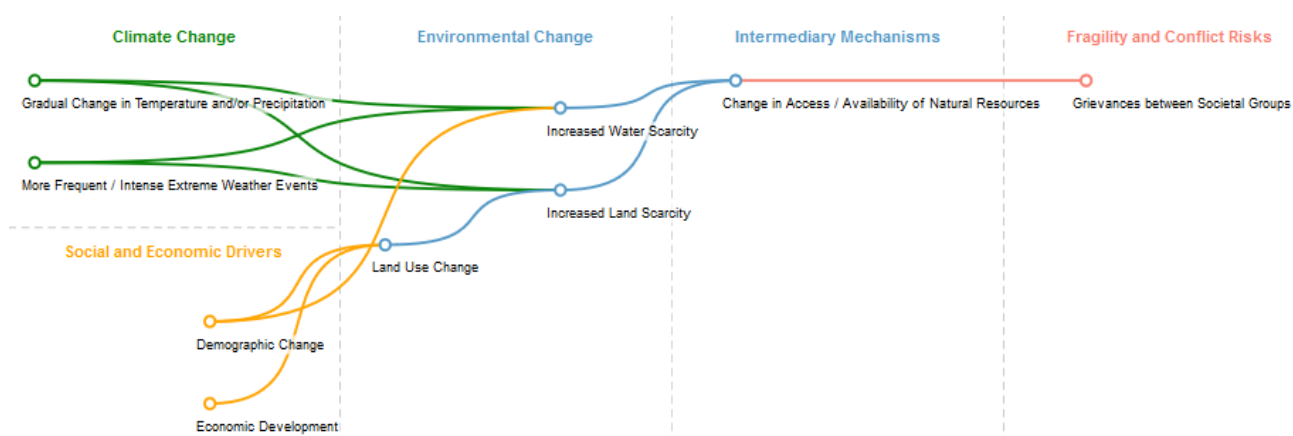
²⁶ "Pastoralist and Farmer-Herder Conflicts in the Sahel | ECC Factbook." *ECC Library*, 16 Jan. 2018, library.ecc-platform.org/conflicts/pastoralist-and-farmer-herder-conflicts-sahel.

²⁷ "Senegal Sub-Regional Conflict Assessment." Sept. 2009, <https://tinyurl.com/y8duhs47>.

²⁸ "Herders vs Farmers: Resolving Deadly Conflict in the Sahel and West Africa." *OECD Insights Blog*, 4 June 2018, <https://tinyurl.com/y7lh6cni>.

²⁹ "Conflict in the Senegal River Valley." *Cultural Survival*, Dec. 1998, <https://tinyurl.com/ycus8qt6>.

FIGURE 2: CONFLICT CONCEPTUAL MODEL³⁰



Climatic change induced events such as increased drought frequency have led many pastoralists to reduce their herds, alter migration routes or abandon their pastoralist way of life altogether. The historic 1970’s drought increased the use of irrigation in the valley, leading communities to minimize their use of customary agricultural practices and become more dependent on non-traditional methods of adaptation.³¹ These developments have contributed to water and land scarcity in the area which are experiencing both heightened migration and conflict. Incremental changes in weather conditions can also engender unanticipated movement onto agricultural land.

Senegal is divided into six agro-ecological zones described in the Figure 2 below. The Sylvo-pastoral and Eastern Senegal zones have been historically the zones with the pastoral activity. Today the development of the irrigated rice production along the River valley has been reducing the land available for pastoral activities. The pastoral-farmer conflicts mostly occur in the so-called “transit” areas, where pastoralists pass-through during the dry season and in which agriculture is rapidly expanding. These regions correspond to the Groundnut basin and Eastern Senegal zones.

FIGURE 3: AGRO-ECOLOGICAL ZONES OF SENEGAL³²



³⁰ “Pastoralist and Farmer-Herder Conflicts in the Sahel | ECC Factbook.” *ECC Library*, 16 Jan. 2018, library.ecc-platform.org/conflicts/pastoralist-and-farmer-herder-conflicts-sahel.

³¹ Ibid.

³² Adapted from Directorate of Water, Forests and Hunting Conservation

2.3 SOCIAL AND ECONOMIC DRIVERS

Social and economic changes within the Sahel have also contributed to the changing relationship between pastoralists and farmers and to the rise of conflicts. Government policies have typically favored agricultural expansion over pastoralism, which has also engendered the expansion of communities on what has historically been pastoral land.³³

Pastoralists continue to be marginalized, with little access to social services, education, markets and opportunities for political participation, often falling outside the scope of government intervention. These factors contribute to the vulnerability of pastoralists to be involved in violent conflicts and international crime networks.³⁴ With little economic integration, poor infrastructure to support social and economic interaction with other communities, high poverty rates, and declining economic growth, there are little opportunities for pastoralists to diversify their means of income and achieve economic prosperity.³⁵

3. NEEDS ASSESSMENT

The following needs assessment is based on a field work, desk review and twelve interviews carried out with subject-matter experts in the Sahel and in Senegal. Throughout our research and interviews, we aimed to identify needs and gaps which guided the project design.³⁶ Our findings have underscored the need for reliable, timely and quality information, technology and enhanced coordination.

3.1 NEED FOR INFORMATION, TECHNOLOGY AND ENHANCED COORDINATION

The current responses to the pastoralist-farmer conflict by governments in the Sahel include: border closings, taxation of incoming herds, enforcement of the transhumant calendar, physical identification of transhumant herders, among other policies, which are fueling more frustrations and tensions.³⁷ These interventions are not in line with the consensus reached in the aforementioned declarations, by which policies must “invest in the prevention of climatic, political, economic and social risks, and in the protection of pastoral mobility,”³⁸ or by which they should aim to “operationalize warning and rapid intervention systems by improving existing information and early warning systems.”³⁹

³³ “Pastoralist and Farmer-Herder Conflicts in the Sahel | ECC Factbook.” *ECC Library*, 16 Jan. 2018, library.ecc-platform.org/conflicts/pastoralist-and-farmer-herder-conflicts-sahel.

³⁴ *New Fringe Pastoralism: Conflict and Insecurity and Development in the Horn of Africa and the Sahel*. Economic Commission for Africa, 2017, <https://tinyurl.com/yc4eg8lx>.

³⁵ *Senegal Sub-Regional Conflict Assessment*. Sept. 2009, pg. 22. <https://tinyurl.com/y794wl7r>

³⁶ Kaufman, Oakley-Brown, Watkins, and Leigh. 2003. “Strategic Planning For Success: Aligning People, Performance, and Payoffs”.

³⁷ Kwaja et al. 2018. Responses to Conflicts Between Farmers and Herders. Search for Common Ground. <https://goo.gl/WeULQo>

³⁸ “N’Djamena Declaration on the Contribution of Pastoral Livestock to the Security and Development”, *participating countries*, 2013.

³⁹ “Nouakchott Declaration”, *participating countries*, 2013.

Reducing mobility has proven to be an inadequate solution in terms of productivity.⁴⁰ Rather than attempting to reduce migration, there is need for sustaining the know-how of pastoral communities while adopting technical developments and information in order to improve their livelihoods.⁴¹ The alteration of traditional seasonal migration patterns poses a noteworthy challenge that could be addressed by stakeholders equipped with quality and timely information.

The table below highlights the needs identified by some of our key informants.

TABLE 1: STAKEHOLDER CONSULTATIONS FOR NEEDS IDENTIFICATION⁴².

Name	Organization	Needs Identified
Dr. Mamadou Ousseynou Sakho	Secretary General, Ministry of Livestock of Senegal	<ul style="list-style-type: none"> • A centralized database for registered conflicts. Due to the administrative division, most conflicts are dealt with on the local territorial level. • Climate services and early warning system dedicated to herders and nomadic pastoralists. • An information system existing that regroups the climate and natural resource information for pastoralists that can also show the change over time.
Amadou Niang	CEO - Millennium Promise (based in Dakar)	<ul style="list-style-type: none"> • Information on changing migrational patterns due to climate change. • A new development philosophy that is not only agriculture based. • Increase data collection in a decentralized and fragmented institutional setup based on agricultural practices.
Christian Berger	Leading livestock, pastoralist and Sahel expert - World Bank	<ul style="list-style-type: none"> • Information to combat prejudice. 'Fake news' has been spreading throughout the region seeking to portray all pastoralists as violent. • Infrastructure and information on livestock population and migratory patterns to help countries prepare themselves to welcome pastoralists.
Jean-Baptiste Migrain	Technical coordinator - World Meteorological Organization	<ul style="list-style-type: none"> • Data management, data sharing policies and institutional arrangements. • Agreements or procedures on what type of data is exchanged, who issues early warnings and how responses are implemented. • Specific tools and data interfaces to be integrated within the existing technologies.
Pierre Sibiry Traoré	Director of Research and Development -Manobi (located in Dakar)	<ul style="list-style-type: none"> • A better understanding of the demand-side in climate information services. • More information about management capacities of different stakeholders.

⁴⁰ Inter-reseaux Development Rural. 2012. "Pastoralism in Sub-Saharan Africa: Know its Advantages, Understand its Challenges, Act for its Sustainability". <https://goo.gl/fFiYEL>

⁴¹ "N'Djamena Declaration on the Contribution of Pastoral Livestock to the Security and Development", *participating countries*, 2013.

⁴² See references for more information on the interviews.

Al Hamndou Dorosuma	Manager of the Climate Change and Green Growth Division - African Development Bank	<ul style="list-style-type: none"> Improve weather information, including weekly weather predictions. Enhance availability of data because it is not necessarily free. Some organizations sell data for profit.
Walter Baethgen	Director, Regional and Sectoral Research Program - IRI, Earth Institute	<ul style="list-style-type: none"> Plausible climate scenarios for the future that include information already available. Integration of the effects of climate change today (rather than in the future) into development projects. Innovative projects that consider year to year variability in climate.

3.2 MARKET ASSESSMENT AND GAP ANALYSIS

Having identified the needs, we then assessed what products and services are being offered, as well as their shortcomings. Several information organizations are present in Senegal, which deliver information around thematic areas, such as Manobi Senegal, for agriculture price/market, and *Ministère de la Santé et de l'Action Sociale* (MSAS) for animal health related information. Several national information systems, including *Agence Nationale de la Statistique et de la Démographie* (ANSD), *L'Agence Nationale de l'Aviation Civile et de la Météorologie* (ANACIM), *Direction de L'analyse, de la Prévision et des Statistiques Agricoles* (DAPSA), *l'Institut Sénégalais de Recherches Agricoles* (ISRA), and *Centre de Suivi Ecologique* (CSE) offer integrative information on two or more thematic areas. ANACIM is the national civil aviation authority and meteorology agency of Senegal and the ANSD is the primary agency responsible for centralizing and dissemination data summaries on agriculture, trade, energy, environment, health etc. generated by the national statistical systems. Some cross-sectoral initiatives and projects have been highlighted in Table 2 below. Additionally, the Ministry of Livestock (MoL) has two information systems operating today: VGtropics, dedicated to the animal health and SIM Bétail which gathers information about livestock markets.

TABLE 2: MARKET ASSESSMENT AND GAP ANALYSIS

Name	Type	Level	Focus	Shortcomings/Gaps
SIPSA - Information system on pastoralism in Sahel	Information System	Regional	Simulating Pastoralists routes, areas and trends.	* Not openly accessible * Last visible update in 2014
Data Roadmaps for Sustainable Development	Initiative under Global Partnership initiative	National + International	Monitoring SDGs with focus on poverty, inequality and climate change	* Focused on broad applications of data to monitor progress on SDGs * More process-oriented and recently launched in 2017
The African Data Cube	Tool under Global Partnership initiative	Regional	Food security, agriculture, water access, deforestation	* Launched in May 2018, very new- needs further development
GeoSenegal	Information repository	National	Repository of Geospatial information	* No Analytical component * Simply a collection of information

DHIS 2	Information tool	National	Health	<ul style="list-style-type: none"> * Focused on Health * Serves as a data collection, recording and compilation tool with basic analysis. No use of big data analytics or AI
OPAL - the Open Algorithms project (OPAL)	Public-Private-People platform and Initiative	National	Various governance issues	<ul style="list-style-type: none"> * Launched in late 2017, very new - needs further development * More of a governance framework to use big data * Plans using big data analytics, mobile data but no AI or predictive techniques
AGRHYMET	Environmental monitoring program	Regional - West Africa	Climate-sensitive issues such as food security, water resources, land use change and natural disasters.	<ul style="list-style-type: none"> * Monitoring hub which collects information on agriculture, environment and other related topics * Has several notable projects like Servir-West Africa which applies geospatial techniques and analysis to enhance the region's resilience to the impacts of climate change and to ensure sustainable land management * Not significant focus on pastoralism related issues and no use of mobile information
Earth Observation for Sustainable Development (EO4SD) initiative	Project	Regional	Urban Development, Agriculture and Rural Development, Water Resources Management, climate resilience, disaster risk reduction, marine environment	<ul style="list-style-type: none"> * EO-based geo-information products and services * No significant focus on pastoralism related issues and no use of mobile information
Famine Early Warning Systems Network (FEWS NET)	Information System	National + Regional	Early warning system, food security, agroclimatology, markets, nutrition	<ul style="list-style-type: none"> * Focus on agriculture and food security * Mobile information not used

Although several information systems are available for agricultural risk management in Senegal, few look at pastoralists and their vulnerabilities. There are many initiatives and programs in the region and the country which utilize Earth Observation (EO) data, but only a handful plan to use big data analytics especially related to mobile information.

4. THE OPPORTUNITY

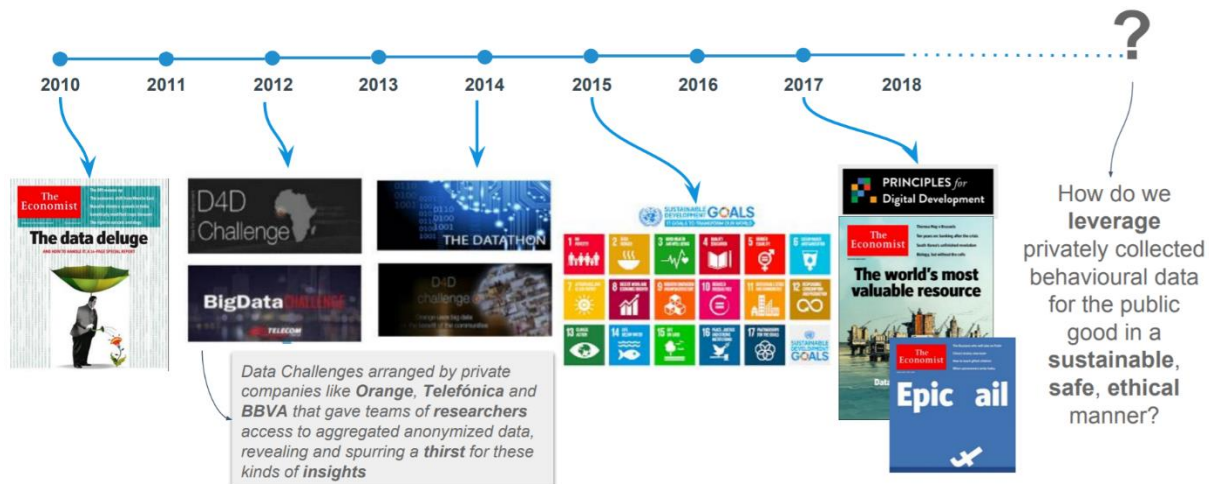
Pastoralism trends and environmental interactions have been studied in the past using various sampling strategies, including surveys, registration data, satellite imagery, and long-term changes in vegetation patterns.⁴³ However, a lot of the methods used are often labor intensive and may occur at a spatial or

⁴³ Ibra Touré et al., "Information System on Pastoralism in the Sahel" (FAO & CIRAD, 2012).

temporal scale that do not capture the full picture, which hampers the development of holistic strategies. Increasing availability and access to quality data through new data streams such as anonymized mobile phone call detail records (CDRs) and high-resolution EO data, combined with climate information, offer an opportunity to enable rapid, large-scale measures of populations and movements.⁴⁴

4.1 HARNESSING THE DATA REVOLUTION

FIGURE 4: THE (BIG) DATA REVOLUTION, EXPERIMENTS, EXPECTATIONS, AND QUESTIONS⁴⁵



Aided by rapid technological advancements and open access movement, never has there been as much information as there is today. At the current pace, almost 2.5 quintillion bytes of data is generated every day and this pace is only increasing with growth of Internet of Things (IoT).⁴⁶ In addition, there is exponentially increasing amounts of data being produced from satellites due, in part, to the proliferation of satellites, improvements in camera technology, and improvements in data storage and transfer capabilities.

4.1.1 EARTH OBSERVATION

One of the sources of big data, EO (from satellite, airborne, and in-situ sensors), provides accurate and reliable information on the state of the atmosphere, waterways, soil, crops, forests, natural resources, and infrastructure. Understanding the change of these factors over time would be invaluable for different functions of government, all economic sectors, and day-to-day activities of society.⁴⁷

⁴⁴ World Bank Group, "Groundswell Policy Note #1: Internal Climate Migration in Sub-Saharan Africa," 2018, <https://tinyurl.com/yathbg3t>.

⁴⁵ OPAL, "OPAL: Status and Plans 2018-19," (2018), opalproject.org.

⁴⁶ Bernard Marr, "How Much Data Do We Create Every Day?," *Forbes*, 2018, <https://tinyurl.com/ydzegj2p>

⁴⁷ Group on Earth Observations (GEO), "Earth Observations in Support of the 2030 Agenda for Sustainable Development," 2017, <https://tinyurl.com/ya3pppc7>

Furthermore, the Committee on Earth Observation Satellites (CEOS) notes that the world's space agencies are currently operating or planning more than 300 different satellite missions, carrying over 900 different instrument payloads, spanning a diverse range of measurements of atmosphere, ocean, and land, which is intended to feed into applications affecting everyday life of common people. A majority of the information generated would be openly available⁴⁸.

The advantages of the EO are numerous, due to the ability of satellites to provide data on all levels, including local, national, regional and even global. Because of their extensive coverage, EO data has the potential to fill important data gaps in data-poor developing countries⁴⁹. EO datasets offer a unique and complementary source of information to cross-check the validity of on the ground or in-situ data measurements (such as survey and inventory data), communicate and visualize the geographic dimensions and context of the indicators and even help generate disaggregated indicators where required. In addition, free and open data is on the rise. The systematic acquisition of data by satellites over long periods of time, (with some mission series dating back to the 1970s and planned up to 2030 and beyond) provides opportunity to track progress, including the establishment of baselines for the determination of future trends, for monitoring, for improved predictions, and for management and mitigation⁵⁰.

4.1.2 MOBILE DATA

Mobile adoption has grown rapidly in West Africa in recent years, helped by the expansion of mobile networks to underserved communities and the increasing affordability of services and device costs. In Senegal, internet usage remains low and is estimated at 21.7%. Conversely, the mobile penetration is approximately 110.74%, with the number of mobile phones, 14,959 million, exceeding the population.^{51,52} There are three main mobile operators that share the market, which include Orange-Sonatel (53%), Tigo (24%), and Expresso (22%).⁵³

Mobile penetration is expected to grow further driven by a demographic shift as young adults take up mobile subscriptions.⁵⁴ Mobile Call Detail Records (CDRs) are a great source of high temporal and spatial resolution data on movements in regions which have high mobile usage and dense tower network.⁵⁵ In addition, increasing mobile broadband or wireless internet access will offer additional avenues to analyze data being collected and generated.

⁴⁸ Ibid.

⁴⁹ Alex de Sherbinin et al., "Data Integration for Climate Vulnerability Mapping in West Africa," *ISPRS International Journal of Geo-Information* 4, no. 4 (2015), <https://doi.org/10.3390/ijgi4042561>.

⁵⁰ Group on Earth Observations(GEO), "Earth Observations in Support of the 2030 Agenda for Sustainable Development," 2017, <https://tinyurl.com/ya3pppc7>

⁵¹ "DataBank." Rule of Law | Data | DataBank. Accessed August 1, 2018. <http://databank.worldbank.org/data/home.aspx>.

⁵² "ARTP SENEGAL." ARTP SENEGAL | Autorité De Régulation Des Télécommunications Et Des Postes. Accessed August 01, 2018. <http://www.artpsenegal.net/>.

⁵³ Viviana Canon, "User Needs Synthesis Report - Open Algorithms (OPAL) Project," 2017, <https://tinyurl.com/ybz3qryt>.

⁵⁴ GSMA Intelligence, "The Mobile Economy - West Africa 2018," 2018, <https://tinyurl.com/yammq8ns>.

⁵⁵ Nita Bharti and Xin Lu, "Remotely Measuring Populations during a Crisis by Overlaying Two Data Sources," *International Health* 7, no. 2 (2015): 90–98.

BOX 1: OPAL PROJECT IN SENEGAL**Open Algorithms**

Recently launched initiatives like the Open Algorithms (OPAL) project which is a collaboration between international institutions, local telecom partners and donors like UN SDSN, AFD and World Bank, offers a great opportunity to leverage and organization to partner with. OPAL aims to serve as a trusted enabler to unlock the potential of data collected by private organizations by bringing the code to the data through open algorithms and safe and fair technological and governance systems. An €1.5M pilot with the governments and civil societies of Senegal and telecom operators Sonatel and Telefónica has been initiated in late 2017 and several use cases are under development in the country.

4.1.3 INTEGRATING ARTIFICIAL INTELLIGENCE AND BIG DATA ANALYTICS

AI applications related to space technology and satellite imagery promise to become some of the most disruptive tools. Major progress in machine learning in the last 5-10 years have made challenging tasks (such as identifying cars, buildings, or changes in landscape over time) doable by machines. This can be applied to imagery analytics and transform the ways in which vast amounts of data from various sources can be interpreted. High performance computing and cloud storage and processing capabilities are making it simpler to handle and apply EO satellite datasets and mobile call records which can be large and complex.

4.2 CHALLENGES AND LIMITATIONS

Information and Communications Technology (ICT) can bridge institutional gaps by integrating informal trade into formal frameworks, strengthening economic development, and reducing trade barriers.⁵⁶ There are many challenges to using the ICT in the context of Sahel and pastoralists. Very-high-resolution imagery (1m resolution) is expensive and is required for most of the commercially viable applications. However, there are several organizations that plan to launch very-high-resolution imaging satellites and if they deploy their constellations successfully, it would drive prices down by significantly increasing availability of satellite imagery.

Mobile data is owned by private companies and gaining access to the information includes long drawn out negotiations and significant legal liabilities. Demographic differences in phone ownership and usage levels within a country can influence the reliability of relative mobility estimates, for example measuring population movements across levels of wealth or rural and urban areas especially in relation to pastoralist corridors.

⁵⁶ Group on Earth Observations (GEO), "Earth Observations in Support of the 2030 Agenda for Sustainable Development," 2017, <https://tinyurl.com/ya3pppc7>.

5. THE SOLUTION: DATA ANALYTICS FOR SUSTAINABLE HERDING (DASH)

DASH is an online data visualization tool which maps and analyzes the spatial and temporal change in migration patterns, seasonality, and urban and agricultural development by using data from EO satellites, mobile, and GPS-enabled systems. DASH will improve the understanding and response to seasonal migration by providing reliable and accurate aggregated information on various factors affecting pastoralists' livelihoods and contributing to the rise in conflicts.

The tool would have an easy to understand and informative dashboard that would alert the user of deviations from the normal by identifying potential areas of resource constraints and violent conflict through the application of big data analytics and AI. The intended primary users of DASH are the Ministry of Livestock and the Civil Protection Department, who will be able to (i) act promptly to avoid imminent violent conflict upon receiving early warning from DASH, and (ii) improve policy making on resource allocation to reduce causes for conflicts in the long term.

5.1 THE DASH-BOARD: USER INTERFACE

The DASH-Board will help visualize the functionalities: (i) a predictive conflict heat map, and (ii) historical data which include transhumance route, climate information, and conflict incidences, available in the menu on the left-hand side of the interface. The user can choose to switch between administrative map view or satellite view using the tabs on the upper-right corner of the interface.



Fig 5: DASH-Board User Interface

5.1.1 HISTORICAL DATA MAP

When the user chooses the Historical Data tab, the menu will expand to show various tier-two tabs such as population density, weather, water points, health service, etc. The slide bar on the bottom works with these historical data too.



Fig 6: Map with Transhumance Route displayed



Fig 7: Map with weather and water points overlaid

For example, the figures above show when the user chooses the Transhumance Route tab, the map will indicate the current or historical transhumance movement routes. The user can utilize the slide bar at the bottom of the interface to choose the date on which the routes are recorded. The user can choose multiple tabs simultaneously and the layers of information will appear on the map at the same time together.

5.1.2 CONFLICT HEAT MAP

When the user chooses the Conflict Heat Map tab, the menu will expand to show sub-tabs for the forecast period of 8 days, 16 days, and 30 days, based on the data update frequency of night time lights imagery through Visible Infrared Imaging Radiometer Suite (VIIRS). When a forecast period is selected, the predicted hotspots of potential violent conflicts will appear on the map in the form of red circles. The larger the size of the circle, the higher the probability of conflict. When the user clicks on the circle, a dialogue box will pop up to indicate the probability of conflict and suggest possible resources needs including water, health service, or grazing land.

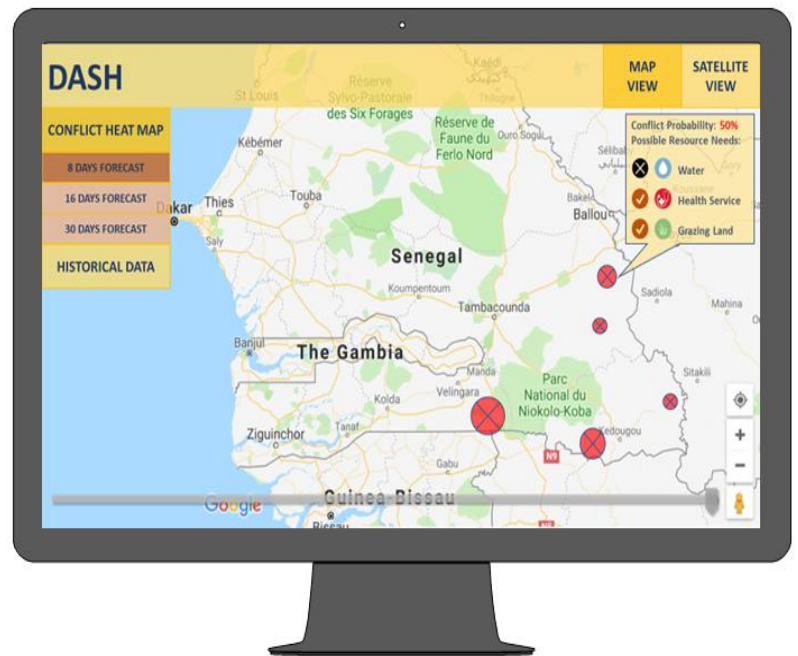
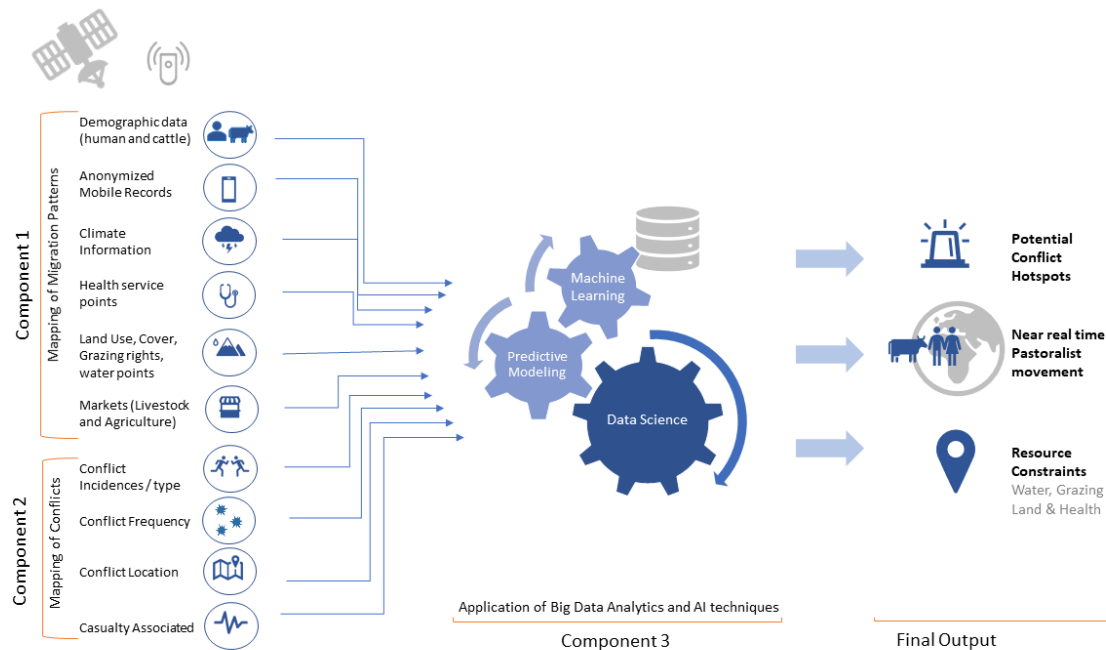


Fig 8: Conflict Heat Map

5.2 DASH: DETAILED DESCRIPTION OF THE BACK END AND FUNCTIONALITIES

Our project aims to integrate different sources of information collected from surveys, remote sensing devices, geospatial satellites, and anonymized mobile call detail records. The DASH tool will have the following three components which will be visualized as described in the previous section.

Figure 9: DASH: Components and Output



5.2.1 COMPONENT I: MAPPING OF THE CLIMATE DATA AND MIGRATION PATTERNS

The main objective of this component is to track and map the current pastoralist migration routes and combine that with climate data such as rainfall patterns, seasonal temperatures, and land use (agricultural expansion and urban growth). By overlaying these various parameters, it will be possible to construct a story of how transhumance routes have changed over time and space and how various factors have influenced these changes. A range of factors (indicated in Table 3 below) will be mapped out using free satellite data from VIIRS, Landsat, MODIS, Sentinel 1 and 2. This component will also help to clearly understand and visualize the current climate, land use and migratory situation.

Installation of relatively cheap camera traps, smart sensors, GPS tracking devices on cattle offer opportunities in the future to complement data received from the satellites. Quality of data collected will only improve with increasing mobile penetration and use of other internet connected and GPS-enabled devices in the region.

TABLE 3: FACTORS FOR DATA COLLECTION

Demographic data (human and cattle)	Markets (Livestock and Agricultural)
Transhumance routes	Night time lights
Climate/Meteorological Information	Anonymized mobile information (Call Detail Records)
Land Use, Land Cover, Grazing rights	Health (human and animal) service points /level
Flow and availability of groundwater and surface water	Vegetation Biomass

5.2.2 COMPONENT II: MAPPING OF CONFLICTS

This component will look at mapping out conflicts over time and space. The source of this information will be from offline data sources like surveys and court records. The conflicts will be categorized based on the type of conflicts, frequency, location and casualty associated, and historical records would be collected as much as possible. The mapping will help us understand the nature and frequency of conflicts, enabling us to draw patterns and insights from it. In addition, information regarding the known or suspected cause of conflict would also be collected as much as possible.

5.2.3 COMPONENT III: MODEL TO PREDICT POTENTIAL CONFLICT

The unification of multiple datasets from disparate sources in combination with advanced analytics techniques and technologies such as machine learning, and AI will be able to develop a predictive model to anticipate patterns of movement and identify potential zones of resource or service pressure points.

For a near real-time estimation, a combination of information generated from different sources will be analyzed. For instance, mobile phones send and receive signals by communicating with the closest cell tower. Each communication event which is billable between the cell phone and tower is logged in the cell phone provider's database of CDRs. This helps in locating a user to the nearest cell tower given the time when the event takes place. This information will be further combined with information such as nighttime lights, as satellite images have the capability to detect settlements by capturing quantifiable, anthropogenically derived light emissions (such as electric lighting and fires).⁵⁷ The size and presence of people can be correlated to brightness value in images.⁵⁸ Service pressure points are areas where there might be an anticipated shortage in supply of a certain resource. The tool will consider access to three services- access to water, grazing land and health services. This information will be used to better understand initial resource constraints and will potentially expand to other services in future. The historical pattern of incidents of conflict along with potential resource constraints would further help derive trends and hotspots.

⁵⁷ P. Sutton et al., "Census from Heaven: An Estimate of the Global Human Population Using Night-Time Satellite Imagery," *International Journal of Remote Sensing* 22, no. 16 (January 1, 2001): 3061–76, <https://tinyurl.com/yalgwcb5>.

⁵⁸Nita Bharti and Xin Lu, "Remotely Measuring Populations during a Crisis by Overlaying Two Data Sources," *International Health* 7, no. 2 (2015): 90–98.

5.3 INSTITUTIONAL AND POLICY CONTEXT

DASH would be developed taking into consideration various existing policy and institutional frameworks to leverage and build upon the work being done and being planned in the future.

5.3.1 INTERNATIONAL FRAMEWORKS

At the international level, the Policy Framework for Pastoralism in Africa, the N’Djamena Declaration, and the Nouakchott Declaration (see Box 2) outline the Sahelian Countries’ consensus on the need for sustainable development of pastoralism.

BOX 2: OVERVIEW OF THE INTERNATIONAL FRAMEWORKS FOR PASTORALISM

Policy Framework for Pastoralism in Africa

In October 2010, the Department of Rural Economy and Agriculture of the African Union Commission published the Policy Framework for Pastoralism in Africa, which sets objectives to (i) secure and protect the lives, livelihoods, and rights of pastoral peoples and ensure continent-wide commitment to political, social, and economic development of pastoral communities and pastoral areas; and (ii) reinforce the contribution of pastoral livestock to national, regional, and continent-wide economies.

N’Djamena Declaration

In May 2013, African countries' Ministers responsible for livestock and security adopted the N’Djamena Declaration on the Contribution of Pastoral Livestock to the Security and Development of the Saharo-Sahelian Areas during the N’Djamena Regional Symposium. The declaration calls for (i) improving governance, (ii) strengthening the resilience of pastoral communities, (iii) enhancing the economic sustainability of the pastoral livestock sector, and (iv) enhancing the social sustainability of communities in the Saharo-Sahelian Areas.

Nouakchott Declaration

In October 2013, six Sahel countries including Senegal adopted the Nouakchott Declaration on Pastoralism, committing themselves to (i) enhance production services, (ii) improve the competitiveness of the livestock sector and market access, and (iii) strengthen the security of the assets, rights, and lifestyle of pastoral people, access to assess be basic services, and political inclusion. Specifically, the Nouakchott Declaration promotes initiatives that strengthen the management of conflicts through prevention and resolution strategies related to access to resources. It does this by acknowledging local authorities and local negotiation and by speeding up the development and enforcement of legal frameworks, such as pastoral codes and land tenure reform.

Other international frameworks such as the 2030 Agenda for Sustainable Development, the Paris Agreement, and the Sendai Framework for Disaster Risk Reduction provide guidance on improving climate resilience and peaceful development of pastoralism. By adopting the Sustainable Development Goals, the UN Member States, including Senegal, specifically agreed to “adopt policies which increase productive capacities...and development of pastoralists” within its strategy to build inclusive and sustainable economic growth as a means for prosperity.

5.3.2 NATIONAL POLICIES

The national policy framework for economic and social development until 2035 - the Plan for An Emerging Senegal (PSE), calls for the establishment of pastoral infrastructures and equipment, the improvement of the product market, animal health and safety conditions, as well as financing. However, there is currently a vacuum of policy framework to regulate pastoralism in Senegal. The most up-to-date and relevant legislation is the 2004 Agro-Sylvo-Pastoral Orientation Law. The law constitutes a long-term strategic framework for agriculture development in Senegal and does not address pastoral activities in detail, only acknowledging that pastoralism adds value to rural space and natural resources. A national pastoral code has been under preparation for several years with extensive stakeholder consultation. The code is expected to adopt best practices from other countries in the region and support the pastoralists' mobility and access to resources.

5.3.3 LOCAL INSTITUTIONAL SETTING

At the local level, the institutional setting around pastoralism is complex. Formal resource allocation such as land tenure, access to water, and conflict resolution managed by local governments tend to favor urbanization, agribusiness expansion, and mining activities. On the other hand, pastoralists traditionally rely on their customary institutions that overlap and compete with formal governance structures. Since pastoralism requires mobility in a large geographic area (sometimes across international borders), the customary governance systems are characterized by flexibility and reciprocity. Territory boundaries and rights to water are negotiated among pastoral groups and sedentary farmers depending on seasonality and evolving weather and market conditions. Pastoralists also have their own traditional solutions to prevent or resolve internal and external conflicts. These distinct features of customary institutions are very difficult to be reflected in formal institution settings. This incompatibility between formal and customary institutions can cause distrust and resentment against government and further marginalization of pastoralist population.

The changing social norms, behaviors, and socioeconomic conditions such as urbanization, penetration of mobile technology, rise of extremism, and especially climate change are also presenting challenges to existing institutional settings. Traditional symbiotic relationships between pastoralists and farmers, involving mutually beneficial exchanges of organic fertilizer and fodder, are vanishing because of climate change and changing transhumant routes. As a result, increasing tensions between pastoralists and farmers are fueling conflicts in the region.

It is also important to note that in many instances, women and men experience participation in both pastoral and farming communities differently. It is imperative to take this into consideration when generating policy recommendations and tools around these communities, where the design of these interventions should reflect gender-sensitive approaches that work to support the specific identities and societal challenges women experience. Through a comprehensive approach to tracking conflict zones, DASH will allow stakeholders to better understand potential gender disparities and be better prepared to

secure women's role as resource managers and community decision-makers. A detailed institution analysis with a political, economic, social, and technological (PEST) analysis is included in annex I and II.

6. PROJECT IMPLEMENTATION

6.1 STAKEHOLDER ANALYSIS

As detailed in annex III and IV, the project stakeholders are categorized into several groups with diverse interests and varied level of influence to the project. The table below summarizes the main stakeholders and their roles in the project.

TABLE 4: STAKEHOLDER ANALYSIS

Category	Stakeholder/Entity ⁵⁹	Role in the Project
Beneficiaries	Communities mostly comprise: <ul style="list-style-type: none"> ● Pastoralists ● Agro-pastoralists ● Farmers 	Benefit from: <ul style="list-style-type: none"> ● Improved security ● Better access of natural resources ● Increased productivity ● Improved income ● Enhanced climate resilience
Project Clients	Government agencies such as: <ul style="list-style-type: none"> ● Ministry of Livestock ● Civil Protection Department Other potential agencies <ul style="list-style-type: none"> ● Humanitarian Aid ● Research Organizations ● Private sector (Insurance firms, Health service providers) 	<ul style="list-style-type: none"> ● Use DASH outputs for conflict reduction and policy making in resource allocation ● Fulfill government mandate of sustainable pastoralism and conflict management ● Provide data for DASH model inputs ● Pay service fee to DASH to ensure project financial viability
Potential Partners	Government agencies such as: <ul style="list-style-type: none"> ● ANSD ● ANACIM 	<ul style="list-style-type: none"> ● Provide sector data inputs for DASH model such as land and water resource allocation, weather and climate information, agricultural and urban development, etc. ● Potential clients for future phases of DASH project

⁵⁹ANACIM = Agence Nationale de l'Aviation Civile et de la Météorologie, ANSD = Agence Nationale de la Statistique et de la Démographie, CILSS = Permanent Interstate Committee for Drought Control in the Sahel, ECOWAS = Economic Community of West African States, IFAD = International Fund for Agricultural Development, IRI = International Research Institute for Climate and Society, WMO = World Meteorological Organization.

	Local partner organizations such as: <ul style="list-style-type: none"> ● Millennium Promise ● OPAL 	<ul style="list-style-type: none"> ● Help coordinate relationships with other partners on the ground ● Take over project operation in long-term
	Mobile network operators such as: <ul style="list-style-type: none"> ● Orange Sonatel ● Tigo 	<ul style="list-style-type: none"> ● Provide anonymous mobile data as inputs for DASH ● Potentially sponsor DASH project
	Academia and research institutions such as: <ul style="list-style-type: none"> ● Columbia University ● Université Cheikh Anta Diop ● Earth Institute 	<ul style="list-style-type: none"> ● Advise on DASH project design and implementation ● Conduct research in DASH related fields
International Organizations	International and regional organizations such as: <ul style="list-style-type: none"> ● World Bank ● UN SDSN ● IFAD ● WMO ● ECOWAS ● CILSS 	<ul style="list-style-type: none"> ● Conduct research in DASH related fields ● Share data with DASH model ● Potentially fund DASH project ● Implement projects that are complementary to DASH ● Policy advocacy

6.2 LOGICAL FRAMEWORK

The project will contribute to the implementation of the Nouakchott Declaration by strengthening the management (through prevention and resolution) of conflicts related to access to resources (including rangelands, water, and land tenure).⁶⁰ The enhanced natural resources management will be achieved through evidence-based and data driven policy making. Also, by reducing violent conflicts in the region, the project will improve the pastoralism resilience and adaptation to climate change.

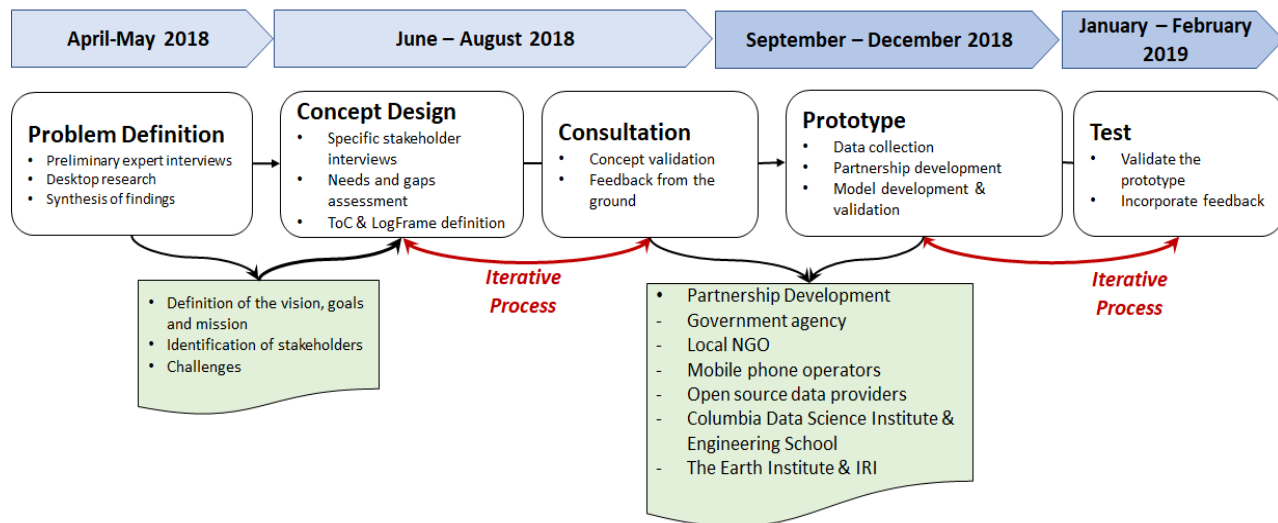
Although this project contributes directly to the implementation of SDGs 1, 11, 13, 15, 16, and 17, it recognizes the interdependent nature of these goals, and therefore fosters an integrated approach to development that relies upon substantive partnerships across sectors, and heavy usage of data and technology, all with the overarching goal of contributing to the central promise of the 2030 Agenda: to leave no one behind. A comprehensive logical framework detailing project outcomes, outputs, performance indicators, data sources, assumptions and SDG contributions can be found in Annex I.

⁶⁰ "N'Djamena Declaration on the Contribution of Pastoral Livestock to the Security and Development", *participating countries*, 2013.

6.3 PROJECT IMPLEMENTATION STRATEGY

The project implementation phases will span a period of 18 months starting from June 2018 and are detailed below in Figure 10.

FIGURE 10: PROJECT DESIGN AND IMPLEMENTATION PROCESS



Currently the project is at the Consultation phase with the objective of validating the concept design with the stakeholders on the ground. The next steps of the project are:

- **Partnership establishment:** The team will extensively engage with stakeholders to form four types of partnerships: (1) Government agencies as the project client; (2) Local organizations as partner project execution and facilitation; (3) Government agencies, international organizations, mobile operators and open source data providers for data sharing; and (4) Columbia University, foundations, private companies and other organizations for project financing.
- **Prototype development:** The team will partner and leverage the vast experience and cutting-edge expertise of the engineering school, the Earth Institute and Lamont-Doherty Earth Observatory at Columbia University to explore the algorithm for the data analytical tool. A coding team will be engaged to develop the prototype.
- **Prototype validation & scale-up.** After the prototype has been tested and validated, various financial sustainability models will be explored. The initial model is outlined in the Annex III, Project Finance.
- **Operation & maintenance.** Project performance and key indicators will be reported based on the project monitoring and evaluation framework as detailed below. The key indicators include the reduction of violent conflicts because of the project.

6.4 PROJECT TIMELINE AND BUDGETING

The project is implemented in three phases: design, development, and operation. The project development phase is further divided into two components: prototype development and partnership establishment. The detailed project timeline and corresponding budget are shown in Annex II and III.

6.5 RISK ANALYSIS

Risks	Mitigation Measures
<p>Government buy-in. Government agencies will be the key users of the data analytical tool; their interest and support are crucial for project success.</p>	<p>The team has conducted a fact-finding mission to Dakar in August 2018 to have preliminary discussions with relevant government agencies, which in principle have interest in violent conflict reduction. The mission will better understand government concerns and needs and incorporate them in project design.</p>
<p>Data availability. The tool needs comprehensive spatial and temporal data to make accurate analysis and prediction. It is important to secure data availability and data sharing agreement with international organizations, national statistic agencies, and mobile operators.</p>	<p>Currently, there are numerous public and private initiatives to push for open data globally and in Africa in particular. There are ongoing efforts in Senegal to make mobile phone data available for research while preserving user privacy. The team will initiate contact with data providers during the mission in August 2018.</p>
<p>Project funding. The project needs funding to invest in algorithm development, as well as operational expenses and up-front expenditures before the project becomes financially self-sustained.</p>	<p>The project does not need heavy investment in equipment or physical infrastructure, so the total project cost is relatively small. The project team will diversify funding strategy and pitch the project to a variety of potential funders such as student competitions, mobile phone operators, government agencies, and foundations with interest in pastoralism.</p>
<p>Competition. Initiatives using climate information and big data are increasing in number, there are also many international organizations and NGOs working in the field of pastoralism. The project should avoid duplication of efforts or reinventing the wheel.</p>	<p>The project team has conducted comprehensive desktop review and has not found any other initiative approaching the problem of pastoralist-farmer violent conflict with similar tools. The team will keep surveying the field during project implementation and make sure that the DASH tool truly adds value.</p>
<p>Geographical distance. The project team is based in New York City while the project will serve clients in Senegal. The team should ensure smooth communication with stakeholders and quick response to the situation on the ground.</p>	<p>The team plans to have at least two missions to Senegal during project implementation. The project team is in contact with several for profit and non-profit organizations that operate in Senegal and are interested in collaboration. The team will leverage local contacts and university resources to ensure that the project fits into local context and is implementable on the ground.</p>

<p>Project sustainability. Once the project tool is built and operational, the operation expenses are not expected to be significant. However, the project should be revenue-generating to be self-sufficient.</p> <p>Also, the team members will graduate in May 2019 and will be located in different parts of the world.,A succession plan should be developed to ensure that the project will survive, improve, and expand to serve its beneficiaries.</p>	<p>Financially, the project will become sustainable after project commissioning by charging a monthly flat fee to the clients to cover operating costs.</p> <p>Regarding human resources and operational sustainability, the project will be handed over to local partner organization or government clients once the project enters stable operational phase.</p>
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7. FUTURE VISION: APPLICATIONS

The potential user of the information system includes everyone who needs climate and market-related intelligence, be it commodity traders, insurers, market research firms, pastoralists and farmers themselves.

Evidence-based policy and decision-making: Our proposed data and information system can provide near real time location-specific information that can be utilized to design effective and relevant policies on local, national and regional levels. It will enable the decision-makers to anticipate the climatic and environmental shocks and stresses, natural resource usage patterns and social dynamics to be able to mitigate the negative shocks.

Planning for future & allocation of resources: Understanding of the patterns of land and natural resource use and change can help better plan for future needs and allocate current resources in a more sustainable way. Various service providers such as insurance, health, education, food, humanitarian aid providers can utilize the tool to efficiently allocate their resources. The information on conflict hotspots and near-real time movement of a mass of people would be very useful for the security agencies in the country to allocate their limited resources in an efficient manner to prevent potential violent conflicts.

Program design and monitoring progress: The tool provides the elements necessary to design and plan effective intervention programs as well as track progress and observe the changes over time to ensure that the set objectives are being met. The collected data can be used to design programs and services targeted for pastoralists. For example, early warning system and climate and resource information services, as well as health, education and market opportunities.

8. CONCLUSION

Given the urgency to act to increase the resilience of the most vulnerable populations to climate-induced shocks and the uncertainty of the current climate prediction models, DASH responds to this need by providing a mechanism to clearly understand and visualize the changes in climate and migration routes. DASH is unique because it aggregates a substantial amount of data from various sources and stakeholders and uses machine learning and AI to analyze and predict pastoralist-farmer conflict which is caused by myriad of interacting factors that can be complicated to understand. DASH is also practical because it provides government agencies with actionable early warnings to prevent imminent conflicts and insights about conflict for evidence-based and data-driven policy making. DASH, as a digital platform, has the flexibility to add new functionalities and be replicated into other geographical areas to support wider needs of existing and new clients for better climate resilience and a more sustainable pastoralism.

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ANNEX I: LOGICAL FRAMEWORK

In line with the Nouakchott Declaration on Pastoralism, the project contributes to strengthen the management of conflicts related to access to resources.								
Impact	Performance Indicators	Data Sources & Reporting	Assumptions	SDG targets contributed to	Related SDG indicators	SDGs contributed to		
OUTCOMES								
1. Reduced violent conflicts because of early-warning from the tool	1a. Incidence of violent conflicts reduced by [30%], from 2020, compare to 2017.	1. Civil Protection Department report	Climate change and other shocks do not become significantly worse to completely offset the government policies and interventions	16.1 Significantly reduce all forms of violence and related death rates everywhere	16.1.2 Conflict-related deaths per 100,000 population, by sex, age and cause			
	1b. Government take action on [80%] of the warnings, from 2020.			11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations				
2. Better understanding of resource constraints and causes of violent conflicts for policy making	2a. Accuracy of prediction of resource constraints and pastoralist migration route reach [90%] by 2019	2. Civil Protection Department and Ministry of Livestock and Animal Production reports		13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries			16.3.1 Proportion of victims of violence in the previous 12 months who reported their victimization to competent authorities or other officially recognized conflict resolution mechanisms	
	2b. Acceptance rate of policy advice submitted to government reach [60%] by 2019			1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters			1.5.1 Number of deaths, missing persons and persons affected by disaster per 100,000 people.	
				15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	13.1.1 Number of countries with national and local disaster risk reduction strategies			
				15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	15.3.1 Proportion of land that is degraded over total land area			

OUTPUTS						
<p>1. Data aggregation and analytical tool created</p>	<p>1. Prototype created and tested by Dec. 2018</p>	<p>1. Project progress report</p>	<p>Funding was secured for project development and implementation</p>	<p>17.8 Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology</p> <p>17.18 By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts</p>		
	<p>2a. Partnership for data sharing formed with international organizations, government agencies, mobile operators, and data providers by Dec. 2018</p> <p>2b. Partnership for violent conflict warning and policy advisory with Civil Protection Department and Ministry of Livestock and Animal Production by Dec. 2018</p>		<p>There is no other significantly better solution that comes out during project implementation</p>	<p>17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships</p>		 

ANNEX II: PROJECT TIMELINE

Activity	2018						2019											
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
1 Project Design																		
1.1 Desktop research	■	■																
1.2 Interviews with experts	■	■	■															
1.3 Identify potential partners	■	■	■															
1.4 Project concept design	■	■	■															
1.5 Geneva Challenge Proposal			■															
1.6 Senegal fact finding mission			■															
2 Prototype Development																		
2.1 Select coding team				■														
2.2 Alpha version development				■	■	■												
2.3 Data collection					■	■	■	■										
2.4 Beta version development						■	■	■	■									
2.5 Prototype completion								■	■									
3 Partnership Establishment																		
3.1 Establish partnership with Millenium Promise				■														
3.2 Establish partnership with data sharing com pnies/organizations				■	■	■	■	■										
3.3 Establish partnership with Department of Civil Protection				■	■	■	■	■										
3.4 Establish partnership with Ministry of Livestock				■	■	■	■	■										
3.5 Fund raising				■	■	■	■	■	■									
3.6 Second mission to senegal							■	■	■									
4 Project Operation																		
4.1 Com missioning of tool										■	■							
4.2 Initial feedback from government										■	■	■						
4.3 Tool improvement										■	■	■	■	■	■	■	■	■
4.4 Continuous monitoring and evaluation										■	■	■	■	■	■	■	■	■
4.5 Explore scaling up to other countries/adding functionalities																■	■	■

ANNEX III: PROJECT FINANCE

The largest component of the project budget is the development cost for the prototype, which is estimated to be \$100,000, other project development costs such as the travel expense for the team, other administrative expenses, and working capital requirement at early stage of project operation will be capped at \$55,000.

The project team was awarded a Columbia University Graduate Global Policy Fellowship of \$5,000 to cover part of the initial project costs. To fully fund the project, the team will seek resources such as partner organizations and enterprise sponsorship. The project financing plan was detailed in the table below.

Sources	Amount	Uses	Amount
University grant	5	Protot ype development	100
Partner organization grant	50	Project development	55
Com pany Sponsorship	100		
Total	155		155

When the project is fully operational, a monthly fee of \$10,000 will be charged to project client to fully cover project operating expenses including, server leasing, project tool maintenance, and administrative expense, so that the project will be financially sustainable without relying on additional grant. Major assumptions used in project budgeting and cash flow projection are listed in the table below.

	Item	Unit	Amount
1	Operation		
1.1	Monthly Government user fee	kUSD/month	10
1.2	Server leasing fee	kUSD/month	5
1.3	Tool maintenance fee	kUSD/month	1
1.4	Travel cost - first	kUSD	4
1.5	Travel cost - second	kUSD	8
1.6	Administrative expenses	kUSD/month	0.2
2	Capital Expenditure		
2.1	Prototype development	kUSD/month	20
	Development period	month	5
	Total development cost	kUSD	100
3	Financing		
3.1	University grant	kUSD	5
2.2	Partner organization grant	kUSD	50
2.3	Company Sponsorship	kUSD	100

The financial projection below demonstrates that the project will have sufficient cash flow to meet the liquidity needs.

<i>In thousand USD</i>	Total	2018											2019							
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	
1	Operating Cash Flow																			
1.1	Monthly Government user fee	180													10	10	10	10	10	
1.2	Server leasing fee	(110)												(5)	(5)	(5)	(5)	(5)	(5)	(5)
1.3	Tool maintenance fee	(18)														(1)	(1)	(1)	(1)	(1)
1.4	Travel cost	(12)			(4)				(8)											
1.5	Administrative expenses	(6)				(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
1.6	Net operation cash flow	-	-	(4)	(0)	(0)	(0)	(8)	(0)	(0)	(5)	(5)	(5)	(5)	4	4	4	4	4	
2	Investing Cash Flow																			
2.1	Prototype development	(100)						(20)	(20)	(20)	(20)	(20)								
2.2	Net investing cash flow	(100)	-	-	-	-	(20)	(20)	(20)	(20)	(20)	-	-	-	-	-	-	-	-	-
3	Financing Cash Flow																			
3.1	University grant	5	5																	
2.2	Partner organization grant	50			50															
2.3	Company Sponsorship	100			100															
2.4	Net financing cash flow	155	-	5	-	50	100	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Net Cash Flow																			
4.1	Net cash flow	89	-	5	(4)	50	80	(20)	(28)	(20)	(20)	(5)	(5)	(5)	(5)	4	4	4	4	4
4.2	Opening cash balance	-	-	5	1	51	131	110	82	62	42	37	31	26	21	25	29	32	36	
4.5	Closing cash balance	-	5	1	51	131	110	82	62	42	37	31	26	21	25	29	32	36	40	

ANNEX IV: INSTITUTION ANALYSIS⁶¹

	Institutions	Influence/Effect	Formal/ Informal
International Policy Frameworks			
1	Nouakchott Declaration on Pastoralism	Serves as a regional policy framework to promote pastoralism. In particular, to strengthen the security of assets, rights, and lifestyle of pastoralist people, access to basic service, and political inclusion.	F
2	N'Djamena Declaration	Reaffirms that livestock activity goes hand in hand with security, and calls for improvement of governance, resilience, and social sustainability.	F
3	Paris Agreement	Global agreement to combat climate change, which promotes resilience and adaptation to climate change.	F
4	Sendai Framework for Disaster Risk Reduction	Serves as an international forward-looking, and action-oriented framework to reduce risks from disasters, including climate change and severe weathers such as drought and flood	F
5	2030 Agenda for Sustainable Development	The overarching international framework for the sustainable development, which calls for efforts to resolve and reduce conflicts.	F
Governance and Resources Allocation			
6	Agro-Sylvo-Pastoral Orientation Law	The law recognizes pastoralism as an activity that adds value to rural areas and commits to a national plan for livestock development. A national pastoral code, which is expected to define the rights of the pastoralists to enhance access to resources and mobility.	F
7	National development strategies and sector policies on mining, agriculture, livestock value chain, etc.	A pastoral code is urgently needed. National sector strategies influence government priorities in terms of resource allocation, such as land tenure, water access, and budget allotment	F
8	Formal governance structure	Often centralized, overlaps and competes with traditional governance structure and usually favors farming communities in terms of resource allocation. Sometimes absent in pastoral areas.	F
9	Customary governance structure	Decentralized, usually guided by the principle of flexibility and reciprocity, which require continuous negotiation with other pastoral groups or agricultural communities.	I
10	Formal resource tenure	Formal resource tenure usually favors urban development and agribusiness expansion, as well as water use for irrigation	F
11	Customary resource tenure	Traditional resources governance acknowledges communal ownership of land and nonexclusive access to water	I
Socioeconomic Institutions, Norms, Behavior, and Conventions			
12	Symbiotic relationship with farmers	The symbiotic relationship is collapsing due to investment in livestock by farmers and crop farming by some agro-pastoralists, which lead to increase tension due to overlapping activities and competition over resources	I

⁶¹ F = Formal institution, I = Informal institution.

13	Changing transhumance routes	The changing transhumant routes due to climate change and expanding crop land causes crop damage and water access competition between pastoralists and farmers	I
14	Penetration of mobile phones	Senegal has a mobile penetration of over 110%. Increasing mobile penetration gives rise to possibilities of <ul style="list-style-type: none"> informing pastoralist of nature resources location, and optimal migration routes better understanding of pastoral system to inform better policy making and violent conflict reduction 	I
15	Criminal activities	Criminal activities such as livestock rustling and illegal trafficking, engaged by only a minority of pastoralists, negatively affect pastoralists’ public image and increase possibility of conflicts	I
16	Ethnicity mix	Pastoral ethnicities are minority in the country. Therefore, they are often marginalized in governance and policy making. Rebellion and irredentism are sometimes based on ethnicity.	I
17	Religious belief	People can be united by religious groups, but young pastoralists are often vulnerable and easily radicalized which add to the potential for violent conflicts	I
18	Extremism activities	Extremism activities cause regional instability and severely destroy pastoralists’ livelihood. Pastoralists are also potential targets for extremist group recruitment	I
19	Livestock and dairy market	Unfavorable market structure and terms of trade exacerbate the high volatility of pastoral production system, which increases the risk of economic stress and violent conflict	F
20	Public perception on pastoralists	Despite their resilient production system, pastoralist unfairly suffer from the prejudice that they are lazy and inefficient.	I

ANNEX V: INSTITUTION PEST ANALYSIS MATRIX

	Political		Economic		Social		Technological	
	Formal	Informal	Formal	Informal	Formal	Informal	Formal	Informal
<i>International</i>	① ② ③ ④ ⑤							
<i>National</i>	⑥ ⑦		⑩		⑧	⑯ ⑳		
<i>Local</i>		⑨ ⑱	⑲	⑪ ⑫ ⑮		⑬ ⑰		⑭

ANNEX VI: DETAILED STAKEHOLDER ANALYSIS^{62 63}

	Stakeholder	+ / -	Interests	Importance (1-5)	Influence (1-5)	Rating Rationale
Key Stakeholders Directly Affected by the Project						
1	Pastoralists	+	<ul style="list-style-type: none"> ● Avoided violent conflicts ● Better access to critical resources ● Better adaptation to climate change and other shocks ● Increase in income and well being 	5	1	<ul style="list-style-type: none"> ● Pastoralists are the project's primary beneficiaries ● The pastoralists are usually marginalized in policy making and thus have limited influence on policy making
2	Agro-pastoralists	+	<ul style="list-style-type: none"> ● Avoided violent conflicts ● Better access to critical resources ● Better adaptation to climate change and other shocks 	5	1	<ul style="list-style-type: none"> ● Agro-pastoralists also benefit from the project ● Agro-pastoralists have limited influence in policy making
3	Farmers	+ -	<ul style="list-style-type: none"> ● Avoided violent conflicts ● Potentially less control on resources 	4	1	<ul style="list-style-type: none"> ● Farmers mostly benefit from the project through avoided violent conflicts ● Farmers have limited influence in policy making
Government Agencies						
4	Local governments <ul style="list-style-type: none"> ● Regions ● Departments ● Arrondissements ● Communes 	+ +	<ul style="list-style-type: none"> ● Improved local security ● Improved local income ● Challenge in institutional arrangement, ICT technology, and capacity building to interface with the proposed project 	4	4	<ul style="list-style-type: none"> ● Pastoralism is only one of many priorities of local governments ● The cooperation with local governments is crucial to the project success
5	Ministry of Livestock and Animal Production	+ -	<ul style="list-style-type: none"> ● Better achievement of the ministry's mandate ● Challenge to allocate resources to interface with the proposed project 	3	5	<ul style="list-style-type: none"> ● The ministry will benefit from peaceful pastoralism ● The ministry will be critical in policy making and implementation for violent conflict reduction
6	Civil Protection	+ -	<ul style="list-style-type: none"> ● Better achievement of the ministry's mandate 	3	5	<ul style="list-style-type: none"> ● The ministry will benefit from peaceful pastoralism

⁶² +: The stakeholder's interest is positively affected by the project

-: The stakeholder's interest is negatively affected by the project

Importance/Influence rating scale: 1 means the lowest, 5 means the highest.

High importance means the stakeholder's interest is strongly affected by the project.

High influence means the stakeholder has significant power to affect the project's implementation

⁶³AGIR = Global Alliance for Resilience, ANACIM = Agence Nationale de l'Aviation Civile et de la Météorologie, CILSS = Permanent Interstate Committee for Drought Control in the Sahel, CSE = Centre de Suivi Ecologique, DAPSA = Direction de L'analyse, de la Prévision et des Statistiques Agricoles, ECOWAS = Economic Community of West African States, EU = European Union, FAO = Food and Agriculture Organization of the United Nations, IFAD = International Fund for Agricultural Development, ILRI = International Livestock Research Institute, IRI = International Research Institute for Climate and Society, ISRA = Institut Sénégalais de Recherches Agricoles, MSAS = Ministère de la Santé et de l'Action Sociale, SDSN = Sustainable Development Solutions Network, WAEMU = West African Economic and Monetary Union, WFP = World Food Programme, WMO = World Meteorological Organization.

	Department – Ministry of Interior		<ul style="list-style-type: none"> Challenge to allocate resources to interface with the proposed project 			<ul style="list-style-type: none"> The ministry will be critical in policy making and implementation for violent conflict reduction
7	Agence Nationale de la Statistique et de la Démographie	-	<ul style="list-style-type: none"> Challenge to allocate resources to interface with the proposed project 	1	5	<ul style="list-style-type: none"> The ministry's operation is not directly affected by the project The ministry's input is critical for the project success
8	Other National Agencies that manages project related data <ul style="list-style-type: none"> ANACIM CSE DAPSA ISRA MSAS 	-	<ul style="list-style-type: none"> Challenge to allocate resources to interface with the proposed project 	1	5	<ul style="list-style-type: none"> The ministries' operation is not directly affected by the project The ministries' input is critical for the project success
International Stakeholders						
9	Neighboring countries	+ +	<ul style="list-style-type: none"> Regional peace Border security and reduced risk of trafficking 	3	3	<ul style="list-style-type: none"> The neighboring countries will largely benefit from a more secured border and peaceful pastoralism The cross-border coordination with neighboring countries will significantly support the project
10	Regional Organizations <ul style="list-style-type: none"> CILSS ECOWAS WAEMU 	+ -	<ul style="list-style-type: none"> Better achievement of the organization mandate Challenge to allocate resources to interface with the proposed project 	2	4	<ul style="list-style-type: none"> Successful implementation of the project will supplement the work of the organizations The organizations are influential in regional pastoralism policy making and implementation
11	International Organizations <ul style="list-style-type: none"> World Bank EU WMO FAO IFAD AGIR 	+ -	<ul style="list-style-type: none"> Better achievement of the organization mandate Challenge to allocate resources to interface with the proposed project 	2	4	<ul style="list-style-type: none"> Successful implementation of the project will supplement the work of the organizations The organizations are influential in regional pastoralism policy making and implementation
Potential Partners						
12	Research institutions <ul style="list-style-type: none"> IRI SDSN ILRI CGIAR 	+	<ul style="list-style-type: none"> The project is aligned with the research institutions areas of focus 	2	4	<ul style="list-style-type: none"> Pastoralism is only one of the research areas of these institutions The project can benefit a lot through leveraging the knowledge and skills of the institutions
13	Partner nonprofit and for-profit organizations	+	<ul style="list-style-type: none"> The project is aligned with partner NGOs mandate 	3	5	<ul style="list-style-type: none"> The partner NGOs are dedicated to the same causes as the proposed project The local connections and relationships of the NGOs are essential to project success

	<ul style="list-style-type: none"> ● Millennium Promise ● Manobi 					
14	Mobile network operators	- +	<ul style="list-style-type: none"> ● Challenge to allocate resources to interface with the proposed project ● Potential to profit from the cooperation 	1	5	<ul style="list-style-type: none"> ● There is not any immediate benefit for the mobile operators except the potential to profit from data provision ● The availability of the data is crucial to the success of the project
15	Third-party ICT/data service providers <ul style="list-style-type: none"> ● Google ● NASA 	- +	<ul style="list-style-type: none"> ● Challenge to allocate resources to interface with the proposed project ● Potential to profit from the cooperation 	1	5	<ul style="list-style-type: none"> ● There is not any immediate benefit for the ICT/data service providers except the potential to profit from data provision ● The availability of the data is crucial to the success of the project
Stakeholders Indirectly Affected by the Project						
16	Dairy industry	+	<ul style="list-style-type: none"> ● Increased milk supply 	3	1	<ul style="list-style-type: none"> ● The dairy industry indirectly benefits from the project and the project impact on the entire industry would be limited ● The dairy industry will not directly affect project implementation
17	Meat industry	+	<ul style="list-style-type: none"> ● Increased meat supply 	3	1	<ul style="list-style-type: none"> ● The meat industry indirectly benefits from the project and the project impact on the entire industry would be limited ● The meat industry will not directly affect project implementation
18	Mining Industry	- +	<ul style="list-style-type: none"> ● Potential less favorable land tenure ● More stable social environment 	3	1	<ul style="list-style-type: none"> ● The mining industry could potentially oppose unfavorable land tenure proposed by the project. But in the long run a stable society free of violent conflict benefits the industry ● The mining industry is likely to have more lobbying power to influence policy making
19	Illegal gangs	-	<ul style="list-style-type: none"> ● Less likelihood to recruit pastoralists 	3	1	<ul style="list-style-type: none"> ● The success of the project will make illegal activities less attractive ● The gangs are a dangerous factor to undermine the project's efforts to reduce violent conflict
20	Extremists	-	<ul style="list-style-type: none"> ● Less likelihood to recruit pastoralists 	3	1	<ul style="list-style-type: none"> ● The success of the project will make extremism less appealing ● The extremist groups are a dangerous factor to undermine the project's efforts to reduce violent conflict

ANNEX VI: IMPORTANCE/INFLUENCE MATRIX

High Importance/Low Influence			High Importance/High Influence		
①					
②					
③				④	
					⑤
⑬					⑥
⑬			⑨		⑬
⑱					
⑱					
⑳					
				⑩	
				⑪	
				⑫	
					⑦
					⑧
					⑭
					⑮
Low Importance/Low Influence			Low Importance/High Influence		

Primary Stakeholders:

1. Pastoralists
2. Agro-pastoralists
3. Farmers

Secondary Stakeholders:

4. Local governments
5. Ministry of Livestock and Animal Production
6. Civil Protection Department – Ministry of Interior
7. National Agency of Statistics and Demography
8. National Agency of Civil Aviation and Meteorology
9. Neighboring countries
10. Regional Organizations
11. International Organizations
12. Research institutions
13. Partner NGOs
14. Mobile network operators
15. Third-party ICT/data service providers
16. Dairy industry
17. Meat industry
18. Mining Industry
19. Illegal gangs
20. Extremists