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Impact of Security Context on Mobile Clinic Activities

A GIS Multi Criteria Evaluation based on an MSF Humanitarian Mission in Cameroon

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Cover photo: Mobile clinic on the way to Batouri (Vincent Muller 2014)

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Master thesis, 30 credits, in Geographical Information Sciences (GIS)

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Abstract

Humanitarian crises require a quick and effective emergency response to answer the needs of vulnerable populations. Deploying mobile health clinics in the field is an example of an outreach activity that can be undertaken for this purpose. This study is based on a real mission implemented by a medical international aid organization (MSF or Médecins Sans Frontières) in Cameroon during the recent Central African Republic humanitarian crisis (2014). All of the knowledge and information required for the analysis have been collected by field observations, interviews and the experiences of the author of this thesis during a 4-month emergency mission in East Cameroon, working as a mobile clinic manager.

The selection of the most suitable mobile clinic sites is a complicated task in such a volatile context. One mobile team can typically cover a number of 8 sites in a two week rotation period (1 site per day, visited every 14 days). Due to a sensitive security and humanitarian situation, a significant number of factors need to be considered before making any decision. This paper shows how GIS can be used to help define the most suitable sites and to what extent the security related factors can affect the final strategy.

Using a Multi Criteria Decision Analysis (MCDA), suitable site areas were identified inside the study boundary via two different analyses: (i) with security considerations and (ii) with no security considerations. Through an Analytic Hierarchy Process (AHP), 13 criteria were divided into three distinctive classes (security related factors, human related factors and environmental factors). AHP helped determine the influence and weight of each factor to one another with pairwise comparisons. It has the advantage of structuring the analysis in a simple and comprehensive way for the decision makers. A Weighted Linear Combination (WLC) completed the AHP method to aggregate the factors and classes together according to their respective weights. A final raster map was generated for each analysis and reclassified into 20 ranges of equal intervals based on the suitability value of each cell. Alternatives were ranked according to their suitability range.

First, the three highest ranges of values were identified as the most suitable areas given security considerations. They cover 1714 km² (3,7 % of the study area) and include 19 relevant towns for mobile health activities.

Second, five of the highest ranges of values were identified as the most suitable areas with no security considerations. They cover 1893 km² (4 % of the study area) and include 18 relevant towns for mobile health activities.
Both analyses only share 10 sites which indicates that the security context significantly affects the site selection in a humanitarian context.

The first analysis (i) was also compared with the actual activities implemented by MSF in 2014 (without the use of GIS). The comparison shows that 9 of the 12 most pertinent sites selected by the MSF decision makers during the 2014 emergency (most visited sites by the mobile clinics) were also selected with the GIS analysis.
The research shows that GIS can be an added value for selecting suitable sites for health mobile activities in a humanitarian context.
MCDAs such as AHP proved to be an effective approach to help in the prioritization process and to limit the alternatives for decision makers. Similar analyses can be used in the future and we suggest keeping them simple and well-structured, especially when dealing with emergency crises where influencing factors are subject to very rapid change.

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Abbreviations

AHP	Analytic Hierarchy Process
CAR	Central African Republic
CNTI	Intensive Therapeutics Nutritional Centre
CR	Consistency Ratio
GIS	Geographical Information System
MCA	Multi Criteria Analysis
MCD	Multi Criteria Decision
MCDA	Multi Criteria Decision Analysis
MoH	Ministry of Health
MSF	Médecins Sans Frontières
MSF-CH	Médecins Sans Frontières - Confédération Hélvétique (Switzerland)
NGO	Non-Governmental Organization
OCHA	Office for the Coordination of Human Affairs
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
WDPA	World Database on Protected Areas
WFP	World Food Programme
WLC	Weighted Linear Combination

1. INTRODUCTION

1.1 Background

For any international aid organization, an effective use of time and resources is essential when responding to a humanitarian crisis. This is usually achieved by the continuous improvement of the working methods from past experiences and by the use of newly available technologies.

Emergencies or post-emergencies projects in humanitarian contexts are developed based on initial field assessments carried out by experienced teams. Swift decisions are then required to start the activities in the best manner. This reactivity is primordial to answer the urgent needs of the communities facing disastrous situations. The experience gained in previous missions is definitely a major asset to save precious time and to be more effective in the field. At the same time, humanitarian organizations try to improve their approach by testing and applying new methods. As technologies expand worldwide at lower costs, it is now possible to use new tools in the field that were not available just a few years ago.

Geographical Information System (GIS) is a good example of a recent technology that could be used to complete initial field assessments in order to help make better decisions. For example, the GIS visualization functions (e.g. base maps) are definitely helpful to the teams on the ground, whether it be to go around uncharted regions, map health promoters' deployments during epidemics or simply keep a visual history of any organization activities. On top of that, more advanced analyses could also be beneficial provided that reliable data is collected.

By integrating different spatial and non-spatial information, GIS can give a good overview of a situation, particularly in identifying gaps (geographical, types of activities, location of potential patients…) and mitigate possible risk of overlap with other partners' projects.

There are more and more GIS applications related to humanitarian crisis and GIS-based analyses offer good perspectives for decision-makers, mostly in terms of site selection or natural disaster vulnerability areas (Verjee, 2007). As such, a mobile clinic project is a relevant opportunity for a practical use of a GIS-based analysis. Mobile health clinics

involve daily movements of resources (human and material) directly where the needs are in order to provide free health care to the beneficiaries.
However, despite all the recent technological advances, humanitarian actions will always be challenged by the context in which the activities are undertaken. Each country has its own specificity and each crisis situation its own rules. The latter can seriously affect the geographical implementation of mobile clinics thus the accessibility of a significant number of refugees. This can mean less potential patients receiving health care. Considering the security aspect is obviously a major imperative for health organizations. No patient can be treated properly if the staff cannot work in safe conditions.

This research work is based on a real world crisis when thousands of people from the Central African Republic fled the civil war violence to find asylum in neighbouring countries (Cameroon in this case). The knowledge and background used to conduct this project directly come from my work experiences with MSF over the past years, especially from the emergency field mission in East Cameroon (2014) during which I worked as one of the mobile clinic managers.

1.2 Aim of the study

The first objective of this study is to assess whether GIS would be applicable to support the decision making process for the implementation of outreach health activities. To do so, the results of the site-selection analysis with security considerations will be compared with the sites actually selected by MSF during the 2014 emergency.
The second objective of this study is to determine to what extent the security conditions of the study area can affect the spatial coverage of MSF mobile clinics locations. This will be assessed by comparing two analyses: (i) with security considerations and (ii) with no security considerations.
This work necessitates a detailed analysis by compiling a lot of data in order to find out where the real needs may be and how to increase the chances of reaching vulnerable populations. GIS is a convenient technology allowing the combination of various types of data that can be spatially localized on a map. With GIS software (ArcGIS 10.2 in this study) data layers can be overlaid altogether according to their importance.

A lot of key information was collected during the field work, such as improvised settlements of refugees, existing health centres, official refugee camps, etc. Each of these factors can influence more or less the final MSF strategy.

In order to support the hypothesis and potentially select the best sites for outreach mobile clinics, several questions need to be answered in the first stages of the research:

- Where are the refugees? Where are they likely to settle once they cross the border? What can influence or limit their movements? Where do they enter the country from? The potential spatial location of refugees must be assessed.
- Are there other health actors and where? Or any other places where to host refugees? The existing gaps in terms of health structure must be clarified.
- Is there any natural or man-made structure that could impact the localizations of the MSF activities?
- What security related factors can influence MSF mobile clinics deployment? In other words, where is it acceptable for MSF to work without putting in jeopardy the staff?

These are the issues that must be considered during the analysis.

The work will also show more practically how a multi-criteria approach based on the analytic hierarchy process (AHP) can help to find out the most suitable sites for mobile health activities.

Finally, the results will be compared with the sites that were actually used during the 2014 emergency mission. This will allow a better appreciation of the added value of a GIS-based analysis in comparison with the reality.

It is important to bear in mind that any GIS study is limited by the reliability of the data collected. This statement is even truer when the factors are related to extreme and volatile human situations and when sources often give unverifiable facts. During such a humanitarian crisis, finding reliable data is difficult, sometimes impossible. Gathering up-to-date information, especially regarding security conditions and refugee locations, turned out to be the most challenging part of the work.

2. CONTEXT

2.1 Regional Context

2.1.1 Central African Republic Civil War

The Central African Republic is a country situated in the central belt of the African continent. It has an estimated population of 5,3 million and covers an area of 622 000 km². Surrounded by six countries, it shares a common border of 797 km with Cameroon in its western part (see Figure 1).

Figure 1: Central African Republic (OCHA 2013)

After its independence from France in 1960, the Central African Republic has known various regimes. In March 2013, a coup took place during which a rebel coalition known as Séléka (mostly Muslim) overthrew the president François Bozizé (a Christian). Following on from this coup, Michel Djotodia became the first Muslim president of the country and decided to dissolve the Séléka. The majority of the rebel groups refused to go along with this plan and dispersed all over the country. Since then, there has been an escalation of violence in the capital (Bangui) as well as in most of the cities and towns of the Central African Republic. From October 2013, ex-Seleka's troops (Muslim rebellion) and "anti-Balakas" (village self-defence forces, composed of Christians and animists) fight each other in which has become a civil war. Exactions against the population are committed by both sides in a vicious circle that could not be stopped despite the intervention of international forces (French military operation).

The situation worsened on January 10th 2014 following the resignations of both the President and Prime Minister.

2.1.2 Humanitarian Crisis

Given this context, the population from Central African Republic that were not involved in fights started to flee their country from the ongoing atrocities. Most of them left their homes with very few items and therefore were short of everything. They hid in the bush to escape from militias and walked for weeks to reach the Cameroonian border. UNHCR sources indicate that people frequently died of "*dehydration, hypothermia or severe anaemia*" (http://www.unhcr.org/537f19309.html).

People who managed to cross the border arrived exhausted and in poor health. Most of the medical cases observed by the MSF teams were related to malnutrition, malaria, diarrhoea and civil war correlated traumas (gunshot or stab wounds). The vast majority of the refugees were women and children.

To avoid paying a right of passage, they sometimes enter Cameroon through the bush before spreading out over the many villages along the border, which is why there is no accurate refugee population number. It is hard to predict future scenarios as the population movements are strongly interconnected with the situation in CAR. However, official statistics (see Table 1) indicate that by the end of May 2014, around 130 000 people reached the East region of Cameroon, among which around 70 000 are new refugees (UNHCR, 2014).

Location	Old Cases (since 2004)	New Arrival (March To Nov. 2013-following March coup d'état)	New Arrival (In Dec. 2013 with the implication of Anti-Balaka)	New arrival (from Jan. 2014 following the resignation of the transitional President)	Total
East	58 071	1 254	0	70 805	**130 130**
Adamawa	38 967	0	463	15 383	**54 813**
North	0	0	0	2 751	**2 751**
Centre	4 076	2 044	238	2 248	**8 606**
Littoral	998	1 851	286	3 246	**6 381**
Total	**102 112**	**5 149**	**987**	**94 433**	**202 681**

Table 1: Statistics of CAR refugees as of 31/05/2014 (UNHCR Cameroon, 2014)

An August 2014 Situation Report specifies that about 125 000 people (84 percent are women and children) have been officially registered as refugees by the UNHCR as of end of August (UNICEF, 2014). This does not include thousands of unregistered refugees scattered along the border, particularly in the East and Adamawa regions.

When being registered by the UNHCR, the refugees receive an official card stating their status which gives them access to humanitarian support (free health care, food distribution…) and the possibility to travel and pass the authorities check points.

Given the limited level of infrastructures in the East region, the sudden increase of population triggered a humanitarian crisis requesting immediate actions. The refugees found asylum in the few UNHCR camps whenever possible. Otherwise they settled among local communities (sometimes former refugees), or built traditional huts in areas allocated by villagers (see Figure 2). The access to water, hygiene and sanitation structures were obviously inadequate to handle such a population, therefore the outbreak likelihood are high (measles, cholera, poliomyelitis, meningitis), especially during the rainy season.

Figure 2: Traditional hut in East Cameroon (Vincent Muller 2014)

2.1.3 Study Area: South East of Cameroon

The border between Cameroon and CAR is 797 km long and includes several known crossing points for refugees (21 entry points are geo-referenced by the World Food Programme as of June 2014, see Figure 4). As specified in the previous section, most of the refugees found asylum in the East region of Cameroon since it is the administrative part of the country sharing the longest border with CAR. The East region covers an area of 109 011 km², which makes it the largest region of the country. With around 800 000 inhabitants, it is also the least populated region of Cameroon (7,3 inhabitant per km²). Apart from mining (important gold and diamond resources) and logging activities, there are very few industries. This is the reason why this part of the country does not offer a high level of infrastructures. A major part of the region is covered by rain forest with a limited dirt road network linking small towns together (see Figure 3).

Figure 3: Typical landscape of East Cameroon (Vincent Muller 2014)

MSF first set up in Garoua Boulai, in the Lom-et-Djérem department but in February 2014, exploratory missions from Batouri revealed that a high number of refugees near Gbiti and in the most southern areas did not receive any assistance. The local health centres did not have enough material and resources to support the growing refugee population. The government or international actors did not expect such an influx of refugees and could not prepare accordingly.

The study area (see Figure 4) of this research covered the regions that are reachable by car from the main MSF base situated in Batouri and from the advanced base in Yokadouma. These towns are respectively the capitals of the two following departments[1]:

- Kadey (covering 15 884 km² and populated by 192 000 inhabitants).
- Boumba-et-Ngoko (covering 30 389 km² and populated by 116 000 inhabitants).

[1] In Cameroon, regions are subdivided into “departments”.

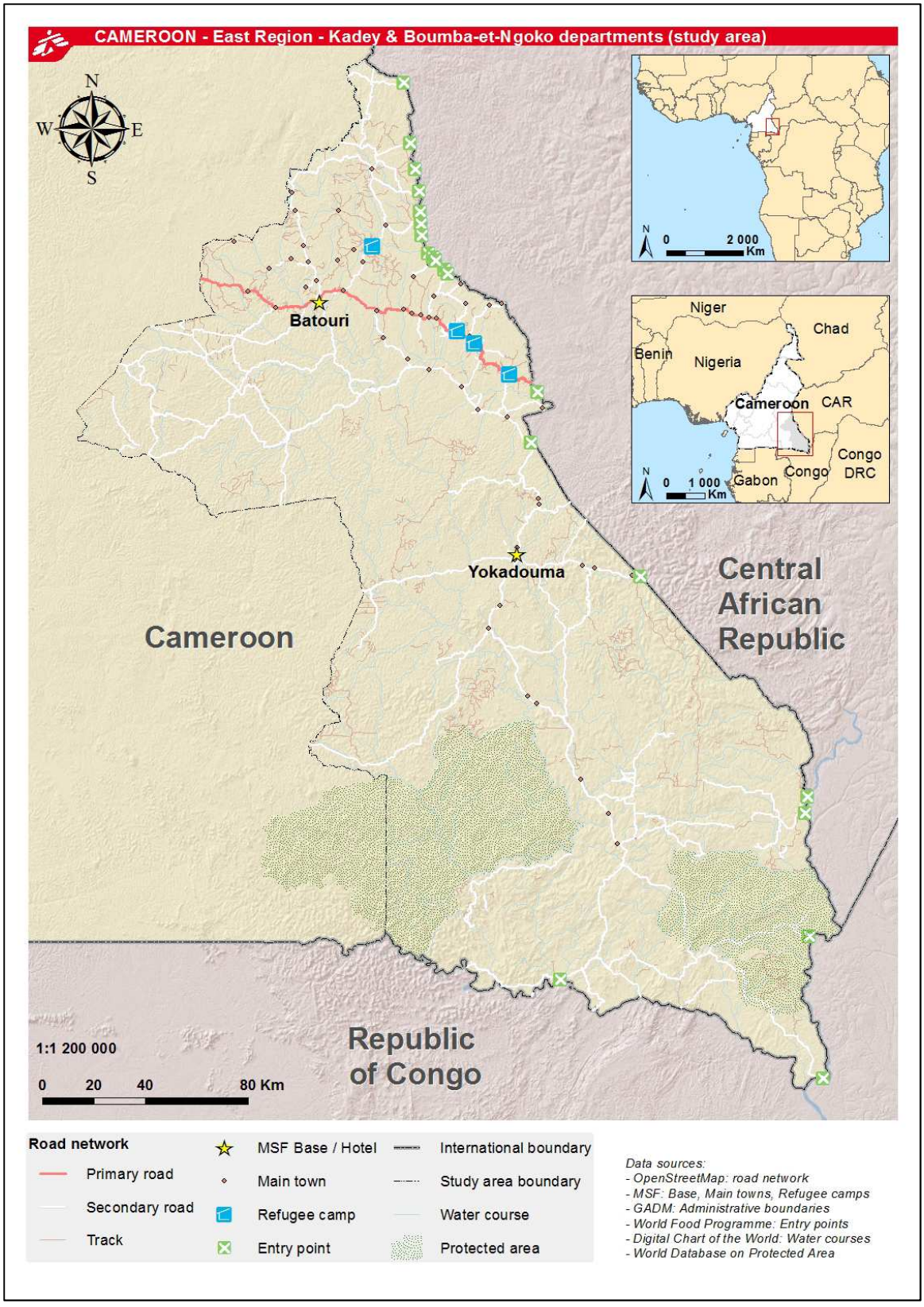

Figure 4: Study area boundaries in East Cameroon

2.2 Humanitarian Emergency Response

2.2.1 About Médecins Sans Frontières (MSF)

Médecins Sans Frontières (MSF or Doctors Without Borders, see Figure 5) is an international medical aid organization that was created in France in 1971 further to the Biafra humanitarian crisis. Their objective is to provide emergency medicine and health care to vulnerable populations regardless of their origin, religion or political party. As communicated in the MSF website (http://www.msf.org/our-finances), more than 5,7 million individual donors around the world provide some 89 percent of MSF funding. It is a fundamental concept for an organization whose "*actions are guided by medical ethics and the principles of independence and impartiality*" (http://www.msf.org/msf-charter-and-principles).

Figure 5: MSF logo

Private donations give the organization the liberty to act merely according to the humanitarian principles, especially in contexts involving multiple parties or institutions. In addition to their neutrality and independence policy, MSF is well known for its principle of advocacy, speaking out publicly whenever they witness unbearable and violent situations.

The organization mostly intervenes in war contexts or in countries facing endemic diseases. The official website (http://www.msf.org/msf-activities) summarizes perfectly their activities. It specifies that "*MSF brings humanitarian medical assistance to victims of conflict, natural disasters, epidemics or healthcare exclusion. They offer basic healthcare, perform surgery, fight epidemics, rehabilitate and run hospitals and clinics, carry out vaccination campaigns, operate nutrition centres, and provide mental healthcare. Their activities include the treatment of injuries and disease, maternal care and the provision of humanitarian aid. Where necessary, they set up sanitation systems, supply safe drinking water, and distribute relief to assist survival.*"

To have a better understanding of the size of MSF, it is good to give a few numbers (http://www.msf.org). As of 2015, the organization has offices in 28 countries, employs around 30 000 staff (expatriates and local staff) and offers health care in about 70 countries.

MSF has received many awards over the last 40 years of its existence, among which the Nobel Prize in 1999 in recognition of its humanitarian aid all over the world during the past decades.

2.2.2 Intervention in South East Cameroon: Why?

Given the MSF principles and motives for action, it is no surprise that the organization has been involved in the humanitarian aid in response to this civil war.

The atrocities perpetrated by the different groups on innocent civilians and the large number of displaced population within CAR and to the neighbouring countries required a significant humanitarian response from the international community. Needs were everywhere in the region and due to the difficulty to anticipate the events, many areas were not prepared to handle the situation.
MSF opened several projects in CAR in the early stage of the war. Several exploration missions in Cameroon indicated that most of the refugees who fled their country had no assistance and needed adequate medical treatment.

Given the high number of people and their bad state of health, an insufficient number of medical structures and the absence of other humanitarian partners at the time MSF arrived in the field, it was decided to open a few projects in strategic areas of the East region. Garoua Boulai and Batouri were used as ”base” locations for each project from where further activities could be launched along the border until the Yokadouma region and surroundings.
It is important to understand that emergency projects are very flexible and subject to the events in the field. Therefore strategies and working locations may change very suddenly. This suppleness allows the organization to meet the needs very effectively by targeting the vulnerable population wherever they are.

The influx of a displaced population being very hard to predict, it is impossible to have a clear scenario of the situation and to forecast its evolution.

When MSF was running initial field assessments, different issues had to be considered:

- The number and size of official refugee camps were inadequate so unofficial camps with poor sanitation were being improvised by the displaced population.
- Very few humanitarian actors were present in the field, particularly in terms of health support.
- The existing governmental health centres did not have the capacity to respond to such an emergency (limited human resources and drugs).
- In spite of malnutrition programs in some major structures, more efforts were required to reduce mortality in this sector.
- Refugees did not receive any basic vaccinations (e.g. measles) due to a lack of available vaccines, which increased the risk of an outbreak.
- The water supply, the hygiene and sanitation systems were limited, not operational or simply non-existent in the vast majority of the places where refugees settled. It was sometimes the source of tension between the local community and new comers in the area.
- Pockets of refugees without assistance needed to be localized, especially since the UNHCR and other partners mostly concentrated their effort and support inside official refugee camps.

These facts indicated what sort of strategy had to be implemented by MSF in order to reach the vulnerable population, to cover the gaps and to avoid overlaps with other partners' activities.

2.2.3 Intervention in South East Cameroon: How?

Beneficiaries

During a humanitarian crisis, before taking action and deciding the type of intervention, it is imperative to identify the target population. In this situation, the priority is to reach and give support to the refugee population in the East region (Gbiti, Batouri, Yokadouma, etc.). In accordance with the MSF principles, and to mitigate inter-community conflicts, the host population will also benefit from the medical support (vulnerable/indigent people). Priority is typically given to children, women and elderly who are more fragile (See Figure 6).

Figure 6: Children visiting the clinic (Vincent Muller 2014)

MSF Objectives

An operational answer requires clear objectives for the organization from which the expected results and the activities to implement can be conceived.

As stated in the logical frame of the project (MSF-CH, 2014a), the main goal of the MSF mission is to reduce and stabilize the mortality and morbidity among the refugee population in Gbiti and in identified pockets of refugees.

To reach this objective, it is necessary:

- To give to the refugees access to a free medical and nutritional support of quality (for mobile clinics and Gbiti camp).
- To give access to drinkable water and functional sanitary structures (Gbiti camp).
- To follow-up outbreak risks and malnutrition situations.
- To support the CNTI (Intensive Therapeutics Nutritional Centre) of the District Hospital of Batouri (malnutrition program) where the most severe cases are transferred from the field.
- To ensure that specific emergency responses are possible whenever necessary.
- To communicate with the press, inform and put pressure on the authorities and other actors (especially the UNHCR) about the refugee crisis and their needs (secure camps, outbreak surveillance, coordination...).

This type of emergencies requires a short to mid-term approach due to the volatility of the context. The objective is not to destabilize any existing health system but to bring support (human, material resources, training) and to handle the influx of vulnerable population, especially in remote areas. Once the situation slowly comes back to normal, a clean exit strategy will be carried out.

The plan will depend on the security situation encountered in the field. Since a large number of refugees are close to the border, it is essential to follow-up the security situation with the help of the local authorities.

Activities

MSF started to work in the area on February 2014, mostly focusing the effort on the Gbiti unofficial refugee camp and supporting the District Hospital in Batouri.

Additional field assessments revealed new needs and led the project to grow with the opening of mobile health clinic activities in areas where there was not enough or no assistance at all.

This study focuses on identifying suitable areas for mobile activities using GIS. Hence, it is important to understand what exactly mobile health clinics in an MSF mission are.

Of course, this is one overview of a mobile activity project. Each mission has its specificity and what works in one country may not work in another country.

Figure 7: Mobile clinic in Gaina, Kadey (Vincent Muller 2014)

The main goal of mobile clinics is to go treat the beneficiaries where they are (See Figure 7). As explained above, the medical support will mainly focus on basic health care and malnutrition.

In terms of human resources, one mobile clinic would usually involve 2 supervisors and 18 national staff dispatched in a convoy of 5 vehicles (See Figure 8):

- 1 logistics manager (security "focal point")
- 5 drivers + 1 logistics assistant
- 10 medical staff + 1 medical supervisor

Local staff will also be hired from the community as daily workers in order to set up the site, control the crowd, translate and promote the activity.

Figure 8: Mobile clinic convoy (Vincent Muller 2014)

There are typically two separate circuits followed by the patients depending on their diagnosis on arrival:

- Circuit 1: classic mobile clinic focusing on basic health care
- Circuit 2: specialized in malnutrition

Each circuit ends with a pharmacy where drugs or therapeutic food may be delivered as per the patients' prescriptions. This partition allows a more effective work thus more beneficiaries treated at the end of the day (See Figure 9).

Figure 9: Mobile clinic setup in Belimbam, Kadey (Vincent Muller 2014)

Depending on the site, the activities may take place under a shelter available in town (school, church, etc.), under a large traditional hut covered by plastic sheeting or in MSF tents. Each MSF employee and MSF item (tent, chairs, tables, drugs...) is assigned to a specific car to ensure that openings and closings of the sites are organized and effective.

Outreach Project Opening

Outreach activities are not improvised and require proper preparation. Before going out in the field to set up the two circuits and to treat the patients, an emergency mission involves preliminary phases formalized by the conception of a project document: (MSF-CH, 2014c) and (MSF-CH, 2014d). In this context, the different steps can be summarized as below (MSF-CH, 2014a) for a better understanding:

- ✓ Field assessment from a reduced and experienced MSF team (medical and logistical) to understand the type of emergency and needs. This team can be sent from the field (if there is already an existing regular project), from the mission coordination (the capital) if there is already a mission in the country, or from the MSF headquarters.
- ✓ Discussions between the field assessment team, the coordination team and emergency unit in the headquarters in order to decide whether an emergency response is required, to what extent and what is the initial action plan. It is important to understand that MSF can work in an area if the organization is accepted by all the parties and local authorities.
- ✓ Once the MSF objectives are clear as well as the size of a project, the different supervisors are sent to the field (usually experienced expatriates).
- ✓ Opening of an MSF base (if not already existing) in or near the humanitarian crisis area. For the duration of the mission, a compound or a hotel can be rented in a strategic and safe town, from where the teams can be deployed and the material can be purchased for the activities.
- ✓ The recruitment of the national staff can start and the material needed to run the activities can be ordered. Logistics, medical and administrative preparations are ongoing.
- ✓ Parallel to these last steps, regular in-depth discussions and assessments can be done by the supervisors to update the information available and collect as much data as possible regarding the situation.

At this stage, a GIS analysis could be involved. It could be used to complete and compile the first data collection and to generate the first results in order to back-up the action plan. This would usually require several days' work, possibly a week or two given the size of the study area. Even though field data are essential for a reliable

analysis, preliminary dataset can be downloaded from the internet a few days before arrival in the field to have an idea of the working area (e.g. OSM layers such as road network, populated places, land cover, etc.). If a GIS officer is deployed in the country, he/she would usually get in touch with the National Bureau of Statistics or National Geographical Department to collect geographical data that are sometimes more accurate or up-to-date than the ones available online. Every country and every emergency mission has its own specific features so it is a complex task to give one general rule. If we take the example of the mission in East Cameroon, a first GIS analysis with the criteria selected in this study could be performed a couple of weeks upon arrival in the field, once the MSF team has had the chance to travel and assess the different regions of the study area for data collection (performed by the GIS specialist or any other team member if required).

Frequency

The goal is to implement a regular schedule so that children suffering from malnutrition can ideally be followed and receive therapeutic food until they are diagnosed as healthy again. A regular visit in the same towns induces that the mobile clinic team can only work in a limited number of places. Indeed, skipping one scheduled clinic would have negative consequences such as the loss of children in the malnutrition program or a loss of credibility if people were to come unnecessarily.

Due to a limited number of working locations and the fact that refugees are often scattered in the villages and distant areas, it is crucial to have an outstanding communication with all the stakeholders (village chiefs, refugee representatives, religious and other community leaders, health centre directors and mobile nurses) so that everyone is well aware of the MSF visit a few days in advance. They can plan their movements accordingly and pass the message around.

During the mobile clinic activities, a local inhabitant will be hired to promote the presence of MSF and remind the population about ongoing activities.

The selection of the sites is a fundamental phase to ensure that the target population will be effectively reached. The timing is important and can make a significant difference. This is why the MSF teams were deployed during the market day whenever possible. Refugees living farther away from a town would usually only come once a week, most likely during the market time. Considering the aforementioned information,

a mobile clinic requires a lot of logistics, coordination and energy. Usually one team would visit four places per week, followed by two days of ”office/base” work (vehicle maintenance, stock management, preparation, reporting, etc.) and usually one day off depending on the seriousness of the situation. According to the number of patients, some sites may require one weekly visit while other sites would only be seen once every two weeks. It is undeniable that the program and the teams need to be very flexible and ready to adapt to any change of situation in the field. However certain stability in the program would help to follow-up the evolution of the health situation in each area covered by the clinics.

2.3 Security Context in South East Cameroon

The main objective of the study is to assess the impact of the security related factors and how they may affect the site selection. To do this, it is important to understand what lies beneath security management.

In such a volatile context where the people flee violence and war, security is an essential component to consider. The location of the study area near the CAR border is definitely a factor to take into account before making strategic decisions. It is good to support vulnerable population but it should not be done to the detriment of the MSF employees’ safety, even if zero risk does not exist. Issues can arise at any time and from different causes. Not all are consequences of the neighbouring civil war.

Security incidents can be caused by a rebel group crossing the border to perform acts of violence or it can simply occur from a snake bite or a heavy rain storm. The danger is not only related to its source but also to the physical remoteness of the team making a quick evacuation extremely complex.

In general, there are three important things to consider before starting activities in unsecure areas, particularly for mobile activities:

- What are the risks and how vulnerable are we?
- How can a security incident be avoided?
- What is the best way to react in different situations if they occur?

2.3.1 Security Risks in the Study Area

In the project area, the main threat identified is the log trucks continuous traffic between the south eastern forest areas and the coastal cities/harbours situated in the west of the country. Both Yokadouma and Batouri are located on the way. Truck drivers' salaries vary depending on the travel time to carry the logs across the country, making them taking more risks and less rest. Their high number and behaviour on the roads is the main hazard. They often drive for hours on bad conditions roads, at a strong pace and with a limited visibility.

There is a high vulnerability when a mobile clinic convoy composed of usually five to six fully loaded cars crosses paths with these trucks. The risks are certainly higher after sunset or when the working site is far from the base (longer distance to travel). Everyday MSF cars will brush past tens of logging trucks. Therefore the accident probability is considered as relatively high in this context (See Figure 10).

The impact of a serious accident involving a fully loaded log truck and one or more MSF cars from the convoy would be extremely high. With four to five passengers per car, such an incident could implicate 10 to 20 people and may lead to the end of the activities for some time, if not indefinitely.

Figure 10: Logging truck accident (Vincent Muller 2014)

There are other significant risks to consider, related to the war context or not:

- Rebel incursions and robberies involving violence (several deaths and attacks were reported along the border during the mission).
- Car accident with a pedestrian or a local villager which could lead to a violent reaction from the local community (e.g. a truck and its cargo were burnt down further to a deadly accident with a local motorbike).
- Roadblocks: intentional blockades may take place at night for robberies. Unintentional roadblock can happen during the day, such as a log truck falling into a ditch. After an accident, they can't be removed easily (See Figure 10).
- Lack of acceptance (previous negative history between NGOs and a local community or false rumours circulating can lead to a strong suspicion towards MSF).
- Snake bites (this region of Cameroon is also the habitat of poisonous serpents), etc.

Anticipation is primordial and if the risks are known in advance, it is possible to prepare for it in the best manner.

2.3.2 Minimizing the Risks

In reality, there is no way to ensure that all the security incidents can be avoided. Longer will last the activities, higher are the risks to run into a complex situation. However, it is possible to highly decrease the odds to face a security issue provided that strict rules are followed by the teams.

For each mission, a security guideline is implemented by the field coordinator and regularly updated according to the evolution of the context.
This guideline is a set of rules and recommended behaviours that should follow the MSF staff at all time.

In the case of mobile clinic activities, different measures can be taken to lower the impact and avoid being in an uncontrollable situation.

Some of them are:

- Briefing the MSF drivers about the hazards on the road and ensure that they follow approved driving rules (speed limit, respect of other road users such as pedestrian or motorbike, systematic car maintenance, etc.).
- Avoiding driving before sunrise or after sunset. Risks are much higher in the dark, especially due to the lack of artificial lights on the roads and the fact that other users often move without any lights.
- Ensuring a good and frequent communication between the cars and the base radio-room so that the teams in the field can always be located.
- Having a precise list of the passengers and material for each car of the convoy, etc.

It is also essential to prepare the MSF deployment in advance by informing the local authorities according to the right communication channels.

In terms of security, anticipation, experience, communication and context knowledge are the key aspects.

2.3.3 Anticipating a Critical Situation

On top of a security guideline, a mass casualty plan with trainings is ideally organised to prepare the staff on how to react when a security incident occurs. It is important to know who does what and when beforehand. Being ready for the worst is the best strategy.

In this project and context, simple measures can be taken when implementing activities such as mobile health clinics:

- Training the staff for a mass casualty plan with clear instructions according to their respective position in the team (logisticians, medicals, coordinators...).
- Dispatching the medical staff in different cars to ensure that a nurse or a physician will always be able to provide a first emergency treatment in case of an accident.
- Carrying Emergency Kits in each vehicle.
- Ensuring regular radio contacts between the base and the convoy.
- Knowing where are located the local authorities and what is the key contact so that phone calls can be given immediately shall a security problem occur.

2.4 Literature Review

In the last decades, international aid organizations have seen their professionalism and methods increase across all categories. It is no longer about being in the field to respond to a crisis but about how effective will be the response. Efficiency in humanitarian contexts will translate into more people saved; more patients treated and improved living conditions. In order to achieve these purposes, relief agencies need to deploy trained staff and utilize any method proving to be beneficial. Geographical Information System (GIS) is a typical example of a technology that can now be implemented in the field in order to help decision-makers to coordinate their program. It has been widely used in various fields as a decision support tool. For instance, GIS were utilized to identify landfills sites for hazardous waste in western Iran (Sharifi et al., 2009). GIS functions were also combined with a multi criteria analysis to select potential locations for wind farm siting in Greece (Tegou et al., 2010). Even if GIS is not yet a very common technique in the humanitarian sector, it starts emerging more and more as aid workers become gradually familiar with its capabilities and the potential applications.

This project also finds its origin on the increasing interest of GIS within MSF and other humanitarian organizations. The recent MSF guidelines developed by the MSF Swiss Logistics Department present a first discussion about the opportunities using GIS in the relief and emergency sector. In the “State of art and opportunities using Geographic Information System” document (MSF-CH, 2013), a technical study has been carried out to assess the use of GIS in MSF projects. It concludes that the vast majority of mapping activities enhancing MSF operations can be conducted with free mapping tools. The authors also specify that GIS is pertinent to improve reporting, handover and emergency responses in general, particularly when related to epidemiological activities. It is an added value for defining target population and locations. However they suggest utilizing GIS with a clear definition of the objectives.

A second project “Development of the Geographic Information System in MSF-CH” (MSF-CH, 2014b) defines a strategy to implement GIS within the organization in order to have a more structured approach of its applications. Based on actual GIS field

activities during MSF missions, this study consolidates the benefit of this technology for the operations.

The dissertation “Utility of GIS Analysis in Coordinating Humanitarian Assistance” (Verjee, 2007) outlines the perspectives of GIS-based analyses in the humanitarian sector and investigates whether GIS could be a good support to make better decision. The researcher highlighted six major categories of GIS uses that could be beneficial in this context, giving an in-depth summary of the situation as well as some interesting suggestions. According to this paper, site selection, vulnerability estimation and gap analyses seem to be some of the most promising applications that can be developed in the sector, on top of more basic visualization purposes. This study covers a lot of aspects but deserves to be backed-up by further GIS experimentations based on real data in order to highlight advantages, drawbacks and limits of the GIS tool in the field. I expect my research work to be one practical example of site selection using GIS in humanitarian emergencies.

The research article “Site Selection Criteria for Sheltering after Earthquakes: A Systematic Review” (Soltani et al., 2014) also brings a valuable input. It shows how important the criteria selection to identify the most suitable locations for sheltering actually is. It first highlights what the major factors are before suggesting what could be the most relevant tool to reach the objective. As such, GIS turns out to be an appropriate method to handle multi-disciplinary criteria while offering a pertinent visual result. The authors report that a very large number of factors may bring too much complexity in the decision making process. They conclude that GIS would be an efficient tool to perform multi-criteria analyses in a decision making process.

Finally, another article (Mladineo et al., 2012) describes how a GIS multi-criteria analysis application can assist in coordinating demining activities. It focuses on the prioritization through the multi-criteria approach. Performing analysis is important to make better decisions but ranking and prioritizing is essential to have a more significant impact without involving complex surveys or costly tasks. Even though involving too many stakeholders in weighting the different variables is not very feasible during an

MSF emergency, it is still a good methodology to manipulate different classes of factors and their influence on mobile clinics site suitability.

The Multi Criteria Analysis (MCA) is a popular method to answer spatial decision problems. Evaluating site suitability and finding the best alternatives are very good examples of GIS-based MCDA (Multi Criteria Decision Analysis). As described in the "Multi-criteria analysis: a manual" (Dodgson et al., 2009), MCA allows the handling of "*large amounts of complex information in a consistent way*" which facilitates the decision makers' work. It is particularly useful when one needs to consider several conflicting criteria in the decision.

Another study by (De Feo and De Gisi, 2014) demonstrates how MCDA can be combined together with GIS in order to identify the most suitable locations in suburban areas for hazardous waste disposal. GIS multi criteria decision analysis can also be very pertinent in other fields, such as natural disaster prevention. Landslide susceptibility mapping is a good example of MCDA application involving GIS capabilities (Feizizadeh and Blaschke, 2013).

Numerous studies showed that combining GIS analysis and MCDA methodology can be a very effective way to help make better decisions.

3. METHODOLOGY

3.1 Theoretical Concept

In order to meet our objectives, it is necessary to determine which methodology should be used. As stated earlier, GIS can combine different information to generate the best alternatives so that better decision can be made in the end. However there are many ways to use GIS and every approach will produce a different result.

In addition, the humanitarian context requires a lot of common sense in every decision and it is primordial to understand the consequences before taking action.
For this reason, the identification of potential mobile clinics sites should follow realistic rules when it comes to the factors influencing the results. Providing health care to the vulnerable population cannot be improvised and a lot of constraints must be considered before going out in the field, particularly regarding the security of the team.
The different steps of the analysis are elaborated in the following subparts.

In this study the most suitable sites will be identified according to each influencing factor. A final outcome will be generated by overlaying the initial suitability maps of each criterion.

As discussed in the previous part, the multi-criteria decision analysis (MCDA) has proved to be effective in selecting sites according to different criteria. The effectiveness of mobile clinic activities highly depends on the location chosen. It is easy to miss the targeted population due to a wrong site selection or a lack of information. Going through the MCDA process helps ensuring that all the criteria available are taken into consideration according to their influence. During this multi-criteria analysis, the analytical hierarchy process (Saaty, 1980) has been used to conduct the weighting process (see Section 3.3, Step 4). Commonly used worldwide, this method has the advantage of comparing the factors in separated classes via a hierarchical structure. This is particularly helpful in interpreting the results and encouraging the discussion between stakeholders.

3.2 Experts' Views

As stated in the introduction, this study is based on knowledge and data from an actual MSF mission in Cameroon during the 2014 humanitarian crisis.

AHP is a knowledge-driven method, requiring input from experts. Their opinions and judgments are essential during the various steps of the process: data collection, criteria selection, weighting of factors and final site selection. To appreciate the reliability of this work, it is important to be informed about the source of the data but also and particularly about the opinions of experts that are using and classifying these data.

In this context, experts can be described as "experienced field humanitarian workers", with solid knowledge of the MSF organization (i.e. principles, security rules, outreach activities and emergency contexts).

Every mission is different and depending on the size and volume and the activities implemented, varying numbers of people may be included in the decision-making process. Running mobile activities in an emergency is usually discussed between the field level, the coordination (capital) and the headquarters (Europe) following the initial field assessments.
On the other hand, choosing where the teams will be deployed is usually debated in the field (with coordination validation) as this is where real-time information is found.

Given this, if a GIS analysis were performed to support the initial plan, the experts involved in the process could be the Field Coordinator, the Outreach Activity Manager and sometimes other departments' supervisors (Logistics, Medical and HR). It is important to understand that every emergency has its own specific attributes and each coordinator or supervisor is welcome to bring his/her own experience to obtain the most pertinent action plan. No matter how many experts are involved, they will make their proposal following a collective discussion and make their judgment according to the most relevant sources available (i.e. key national staff, local authorities, other actors, etc.).

This study is based on actual knowledge from the field. However, it was performed after the mission took place as a way to appreciate whether GIS could have been beneficial in this situation. Having worked as a logistics manager myself in the MSF mission on which this case study is based, I applied my own expertise and knowledge of the field to this research project. I was in charge of one mobile health clinic between July and October 2014, thus I became very familiar with the context, our impact and the limits of the activity.

During our work, I often discussed and exchanged ideas about our strategy with other MSF coordinators, experienced colleagues from different backgrounds, as well as with the national staff, who are very knowledgeable about the context and local culture.

Being in the field daily as a focal liaison and logistics manager, I am well aware of the challenges met when running outreach activities, whether it be to collect reliable data about the refugees (i.e. locations, number), contact with the local authorities and community leaders, and follow up about the security situation to ensure that the activities ran smoothly and without incident.

In addition to this field mission in Cameroon, I have worked with MSF since 2010 in seven other countries as a logistics manager or as a GIS officer. I had the opportunity to experience and understand all type of contexts, including: earthquakes (Haiti), conflict areas (DR Congo, Afghanistan, and Lebanon), malnutrition (Chad) and epidemic outbreak (Ebola in Guinea and cholera in South Sudan).

My combined years of field experience in addition to input from my experienced humanitarian colleagues allowed me to develop an “expert opinion” that helped in appreciating the influential factors and building a realistic AHP structure such as the one proposed in this study.

3.3 Implementation Process Overview

Figure 11 shows the different steps undertaken during the process.

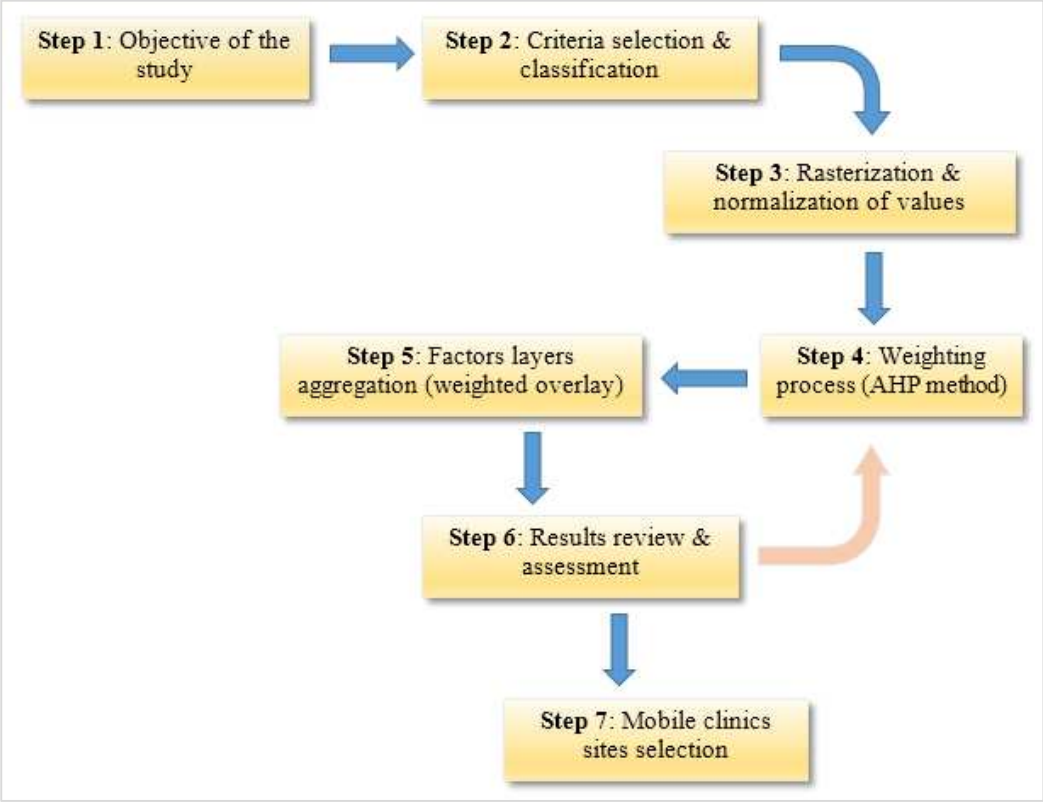

Figure 11: Implementation process diagram

Step 1: **description of the objective.** In this case, we want to find where the most suitable places for mobile clinic activities are and review the influence of the security in the result.

Step 2: **selection of the criteria.** What can influence the implementation of these activities? What are the factors and do we have a geographical knowledge of them? Is there any constraint? See section 3.5 for details.

Step 3: **standardization of the criteria**. In order to perform a good analysis and make reasonable comparisons, the values of factors must be converted into a predefined common scale. This process requires the transformation of the vector layers into their respective raster layers depending on how we want to define the suitability areas for

each dataset. The knowledge of the reality in the field is very important to select the most relevant GIS algorithms. See section 3.6 for details.

Step 4: **weighting the criteria.** This is a crucial stage in the MCD analysis. Producing suitability maps for a specific objective relies on a rather complex knowledge of the context, the goal to achieve and their influential factors. The reliability of resultant maps mostly depends on the selection of the appropriate methodology of analysis and modelling. The process of generating suitability maps involves several qualitative analyses that are based on the opinions of experts. There are a wide variety of qualitative methods which could be used for weighting purposes in GIS analysis. Analytical hierarchy process (AHP) is one of these methods and provides a flexible and easily understood way of investigating complex problems (Yalcin, 2008). This methodology has been utilized in many studies. For example, in a recent research article (Kumar et al., 2015), an interesting comparison was performed between weighting assessments techniques to analyse site suitability. It indicated that AHP with its pairwise comparison approach is more appropriate in terms of accuracy than other methods.

Other studies also demonstrated the added value of AHP as an effective approach to handle multiple criteria for site selection, especially in a multi-level structure (Moeinaddini et al., 2010 and Mishra et al.; 2015) . Since this project involves 13 criteria, dividing them into classes while maintaining accuracy seems to be the most reasonable method.

Unlike other popular weighting methods such as WLC, AHP allows the active participation of decision makers in finalizing weights and gives a rational insight into the logic beyond each set of weights (Yalcin, 2008). This can be very helpful in this study since we need to convince all the stakeholders in the field that the results are reliable, so that the maps can be used in their activities. In addition, it is more suited for the typical MSF group thinking approach where a lot of people can be involved in the decision making process.

AHP (Saaty 1980) also provides a test index, called Consistency Ratio which enables the verification of experts' opinions. This aspect is ignored in other popular methods such as WLC.

As pointed out earlier, the method has the advantage to decompose the problem into different classes through a hierarchy structure. This technique is particularly useful in situations where a lot of factors can influence the operations. Due to the complexity of the humanitarian context, it is more intuitive to compare together the same type of criteria instead of ranking them all in one specific order.

The AHP method involves the construction of a comparison matrix where each criterion will be compared and ranked with other criteria from the same class, using a scale from 1 to 9 (Saaty, 1980):

- 1 indicating that both criteria are of equal importance.
- 9 meaning that one of the criteria is extremely more important than the one it is being compared with (see Table 2).

Preference factor	**Degree of preference**	**Explanation**
1	Equally	Two factors contribute equally to the objective
3	Moderately	Experience and judgment slightly to moderately favour one factor over another
5	Strongly	Experience and judgment strongly or essentially favour one factor over another
7	Very strongly	A factor is strongly favoured over another and its dominance is showed in practice
9	Extremely	The evidence of favouring one factor over another is of the highest degree possible of an affirmation
2, 4, 6, 8	Intermediate	Used to represent compromises between the preferences in weights 1, 3, 5, 7 and 9
Reciprocals	Opposites	Used for inverse comparison

Table 2: The pairwise comparison scale (Saaty, 1980)

Once the comparison matrix is complete, a Consistency Ratio (CR) is calculated to ensure that comparisons are consistent (in other words, if factor A is more important than factor B and B than C, then A should be more important than C). If the CR value is lower than 0,1 the matrix is considered to be consistent enough and the calculated weight values shall be used during the criteria aggregation (the sum of all the weights equals to 1).

Step 5: aggregation of the criteria. Once the weights are generated for each factor and provided that the consistency ratio is below the 0,1 threshold, the different raster layers can then be overlaid. This operation is done using ArcGIS Weighted Sum algorithm which will multiply all the cells of each raster layer by the calculated weight before adding the resulting raster layers together. It will generate a map where low value cells would indicate a lower suitability and high value cells a stronger suitability. In this research, summation is a more appropriate calculation technique than multiplication between layers. Due to the large variety of criteria, it is indeed not reasonable to give too much influence to the cells having their value close to 0.

Step 6: verification of the initial results. The resulting map from Step 5 will be reviewed to ensure that it fits the reality of the field. Some corrections may if necessary, for instance during the pairwise comparison.

Step 7: selection of the mobile clinic sites. To obtain a more usable outcome for the activities, a certain number of sites should be selected from the most suitable areas. Considering that one mobile clinic team can visit 4 different sites per week, 8 sites should be identified as potentially most suitable.

Because we want the final proposal to be as reliable as possible, the selected sites were based on known populated places whose geographic coordinates have been recorded by MSF during the field assessments. These locations are usually large enough to have a weekly market and/or a religious structure where the surrounding population (locals and refugees) gather weekly. Working in the most suitable sites is important but visiting these sites at the right moment (e.g. market day) is even more crucial.

In reality, it is wiser to avoid being too restrictive in terms of alternatives and to keep some flexibility in the final list. For this reason, a higher number of sites (about the double) will be highlighted to ease the decision making process and allow additional discussion based on criteria that cannot be spatially geo-referenced: NGO acceptance, reality of the field, confirmed presence of refugees, minimum distance between sites, etc.

3.4 Field Work & Data Preparation

3.4.1 Data Collection

This research work was based on data collected prior to and during my 2014 field mission in Cameroon. Due to the volatility of the context, it was extremely hard to gather reliable information, particularly in terms of refugees. Sources in the field were not always consistent and information often needed to be double or triple-checked during the visits.

Different types of data were initially collected:

- Data classifying the events with a lot of concrete information: number of refugees, their location, health status, movements, activities...
- Data describing the behaviour of the refugees in relation with their new environment: e.g. how long does it take them to reach the closest health centre?

The MSF data collected during the field mission were not specifically compiled for GIS purposes but mostly to get a better overview of the situation. Knowing that the effectiveness of outreach activities relies on a good knowledge of the study area and of the influencing factors, several key questions had to be answered to have a better understanding of the situation.

- Relative to security: What is the current context in the region? Were there any security incident and where? What is the road network of the region? Where are the borders? Where are the refugee entry points?
- Relative to human activities: Where are the "pockets" of refugees? Where are the populated places and most significant towns? What is the distance and travel time between the towns? Where are the existing health centres situated and what area do they cover? How many official refugee camps are open and where are they? Are there other NGOs working in the area and what type of activities do they implement?
- Relative to the environment: What type of land cover is typical of the study area? Where would the refugees tend to settle down in regards to the land cover? Is there

any restricted area where they would not go and where we could not open clinics? Do they have easy access to water? If not, where can they find water?

3.4.2 Data Sources and Contacts

Before starting field operations, MSF needs to meet with the authorities. If the organization is not in the country yet and depending on the policy of each country, contacts with the Ministry of Health is normally required before any action can be taken.
At the time the humanitarian crisis emerged in Central African Republic, MSF was already running a few projects in Cameroon. That is why the organization could follow up the events closely and trigger a quick emergency response.

Three levels of contacts typically take place during a mission involving a large number of stakeholders: the coordination level (country capital), the project level (study area capital or MSF base) and the field level (field).
The MSF coordination situated in the capital of the country would usually be in contact with the higher authorities of the government (ministries) and other international organizations or NGOs working in the country. In our case, initial contacts were already made due to the presence of MSF in the country before the crisis.

At the project level (study area), the MSF field coordinator will be in regular contact with the highest local authorities (prefects, deputy prefects, police force chief, military commanding officer, MoH local representative) to follow-up the emergency situation, inform about the MSF activities and get the latest security updates. He/she will also be in touch with other NGOs or international organization (e.g. UNHCR) working in the area to share and collect information (NGOs projects or plans, their locations as well as official refugee camps can be obtained through this channel).

In the field, the MSF mobile clinic focal point or team leader will have daily contacts with people met during the activities or while doing the field assessments.

Anyone encountered can potentially share interesting information but a few key stakeholders should be interviewed to collect relevant data:

- Village chiefs and/or refugee representatives: they will usually have information about the locations of the refugees in their area of influence. The best case scenario is that they share an accurate list with a clear number of refugees. Alternatively they could provide with a rough estimate of their number. We requested to have a list made whenever possible to have a better idea of the refugee population.
- Law enforcement authorities (army and police): they can be found at their local offices, at their various road checkpoints or directly in the towns, especially during the market days. They sometimes share relevant information regarding security (e.g. rebel incursions) and areas to avoid as well as the movements of the refugees.
- MoH health centres directors: they have information about the refugee locations and can also share the position of the different health centres in the study area. They are the best contacts to know about the health situation in the region (ongoing issues, risks of epidemics, vaccination campaigns, shortage of drugs, etc.)
- "Relais communautaires" (community relays): they support their communities in terms of health and promotion. Because they travel quite a lot in the area, they are very knowledgeable about the situation and can also inform MSF about the refugee situation.
- International and/or humanitarian organization working in the field (e.g. UNHCR refugee camp manager, Red Cross field workers). They need the same information as MSF in order to adapt their activities to the reality of the field, therefore they will also have relevant data to share about the security situation, the refugee locations, the need of official refugee camps, etc.

Any movement out of the MSF base is a good opportunity to meet any of these stakeholders and to update the data previously collected.

Compiling reliable information requires lots of interactions with the aforementioned sources. This volatile context is such that the same questions must be asked every day

in order to recheck, confirm and/or update the information. It is crucial to do so to make better decisions. Our health activities will only be effective and consistent provided that we managed to compile trustworthy information. In a humanitarian and sensitive context, it is usually the most challenging part of the work.

As described above, there are many different stakeholders and they all have a piece of information that they may or may not be willing to share. Many aspects need to be considered while gathering the data. Everyone has a different role to play and an objective. A refugee group representative trying to improve living conditions of his people will not have the same goal as a Cameroonian village chief who does not have enough water points for his own population. It is important to try to understand their situation and purposes in order to appreciate the reliability of the data shared.

Extreme circumstances can affect reliability. Is the informant under pressure? Has the informant any interest in biasing the information? Is there any tension with the refugees? Because of the complexity of the context and the need to collect a first set of data very quickly, we had to use different approaches for different informants:

- Simple conversations with authorities, village chiefs and refugee leaders (with key questions, to gather quick data).
- Unstructured interviews when accepted/possible with a key informant (e.g. with a Relais Communautaire).
- During the first clinics, a Cameroonian MSF staff specialized in Communication & Education would meet key informants and other sources for purposes such as:
    - Training in hygiene promotion to open a discussion, where he will act as moderator (sort of focus group).
    - Asking the people newly trained to pass the message to the population and refugees and to help in detecting malnutrition cases (sort of participatory approach).

The last method is a good way to inform the community about MSF, to gain their trust and to confirm the data initially obtained through conversations and interviews.

The reason to involve a local staff in this task is obviously because he knows exactly how to behave within the communities, how to approach them in the most suitable manner and what language or dialect to speak. This data collection method seems complex but it can be a lot of work to gain trust. Team work and a high flexibility in data collection methods is crucial to access useful information view the large diversity and roles of the informants (refugees, Cameroonians, soldiers, local politicians, other NGOs, etc.)

On top of field data collection, additional dataset were downloaded or created using several sources on the Internet:

- MSF => refugee locations, camps locations, international health NGOs, populated places, most significant towns
- The OpenStreetMap project (http://www.openstreetmap.org) => roads, populated places, built-up areas
- Portal FBP (Ministry of Health in Cameroon, http://www.fbrcameroun.org/) => health centres and their district
- The Food and Agriculture Organizations of the United Nations (FAO, www.fao.org) => land cover
- The World Database on Protected Area (WDPA, http://www.protectedplanet.net/) => reserves and national parks
- Global Administrative Areas (www.gadm.org) => administrative boundaries of Cameroon and neighbouring countries
- Digital Chart of the World (www.dcw.og) => water courses

3.5 Influential Factors of MSF Mobile Clinic Activities

Mobile clinic activities in such a sensitive context are a challenge. The administrative and political aspect (such as the communication process with the authorities) prior and during the activities are not going to be discussed in this study but it is important to understand that despite all the criteria considered in the project, other factors can strongly influence the MSF plans and bring them to an end from one day to another.

MSF, such as any other NGO, can only carry out health activities with the authorities and local communities consents. This acceptance depends a lot on the communication made by the organization but also on less controllable factors such as activities and relationships built in the past, by previous MSF missions in nearby areas or by any other NGO or structure perceived as such.

This "humanitarian" history can be an asset or an inconvenience and can vary a lot from one village to another. It is important to be aware of this but it is impossible to consider such influence in the spatial analysis. Acceptance is an ever changing factor that would take a long time to map. However it will be used in the field as one of the final aspect once the most suitable sites have been identified.

In general, three groups of factors can be pointed out in this context:

- Security/safety related factors
- Human related factors
- Environmental factors

Mobile clinics being a very particular activity, there is no official study or standard indicating what should be the criteria to consider. They are very dependent on the context where it takes place, on the means available and on the experience of the different coordinators in charge of the project. Different experts would probably select different criteria or weight them differently. The 13 factors listed below are based on common sense and on the reality of the field in East Cameroon. The availability of the dataset also played an important part in the number of influencing factors.

3.5.1 Security/Safety related Factors

These factors relate directly to the security or safety of the team and of the beneficiaries. Before trying to help vulnerable population, it is essential that the MSF staff can work in an environment as safe as possible. For this reason, some security rules are implemented and must be followed at all time. Security incidents are exceptions that usually occur when rules are not updated according to the context or not followed properly. However, despite of the existence of a good security guideline, there will always be events that cannot be controlled or anticipated. This being said, a good follow-up of the situation and a professional behaviour will highly decrease the risks of being affected. The site suitability analysis takes into account the security as one of the main influences. This research work will also show how much this insecurity can affect the action plan.

Four factors have been identified in this group (see Figure 13):

- Distance to/from the MSF base → Mobile clinics should be implemented close enough to ensure that the team is back to the main base (Batouri) or to a secure hotel (Yokadouma) before dark (see Figure 12). Driving at night, especially with five to six MSF cars in convoy, critically increases the risk of an accident with one of the many logging trucks continuously crossing the region at high speed. In addition, there is a larger risk of collision with other road users (motorbikes, pedestrians, animals) that could turn the community against the NGO. Finally, moving on bumpy dirt roads several hours per day is very tiring, for the drivers and the vehicles occupants. The team should have enough time to rest in the evening and Cameroonian labour code must be followed for the national staff.

Figure 12: Driving back to base before sunset (Vincent Muller 2014)

- Distance to international border → Due to the ongoing civil war in the Central African Republic, there have been several attacks from rebel groups crossing the border illegally to rob the population. Most of these incidents took place along the border line. Therefore, and for obvious reasons, it is more hazardous to work very near the border even though chances of finding refugee populations in the area can be higher.

- Distance to entry point → These are places identified as the major entry points to Cameroon for the refugee population. For security reasons, these refugees won't stay right near the checkpoint since there is a higher risk of being attacked. However, they won't settle down too far away either, because they had an exhausting journey, sometimes arriving in very bad condition, and also because they are not always allowed to move farther away without being officially registered as refugees with the UNHCR.

- Distance to roads → For security reasons, MSF employees should not work too far away from the MSF vehicles that transported them in the field. In the event there is any incident requiring an evacuation of the team (e.g. shootings, rumours about oncoming fights, etc.), the mobile clinics supervisors should be able to gather the team quickly. Furthermore, hourly radio checks between one car and the MSF base require the contact person to actually have the team within sight. In terms of logistics, it is also complicated to unload all the material and carry it on long distances.

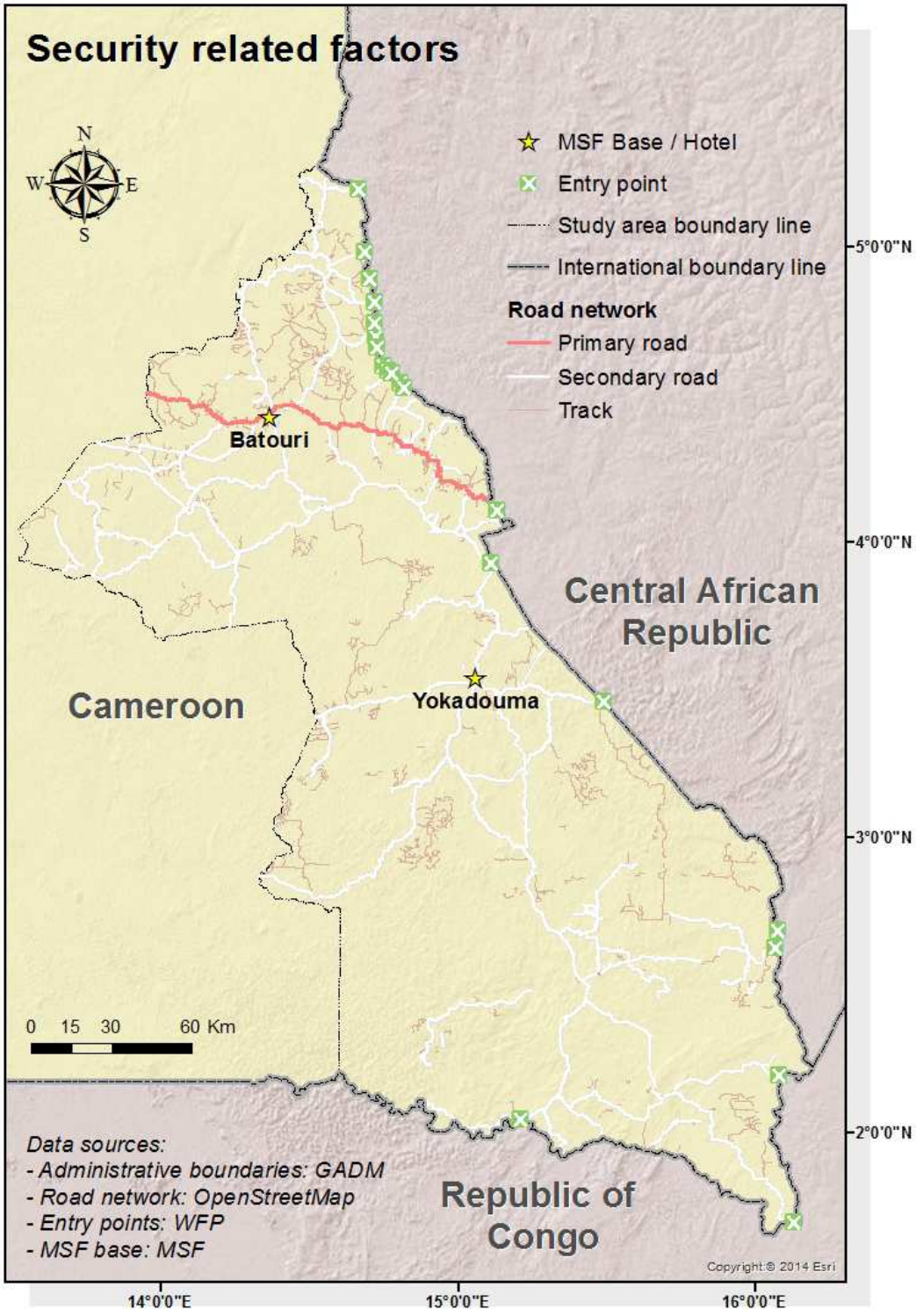

Figure 13: Security related factors

3.5.2 Human related Factors

This class represents the made-man structures and infrastructures or the localizations of populations (see Figure 14 and 15). Refugee groups will tend to come closer to these places to find asylum, support and work whenever possible. However, the MSF objective is to reach the most vulnerable population, which is not necessarily the one situated nearby human structures such as health centres or refugee camps.

- Refugee population density → This factor is essential as it is directly based on the field work. It was not possible to assess every single area but the key spots where refugee "pockets" could be found were assessed during the first days/weeks in the field. Data was shared by community leaders or village chiefs, depending on the person centralizing the information. As expected in such a context, there can be important movements and the population number can vary from one week to another. However it makes more sense to try and work near areas where refugees are known to be found in higher numbers. These places should be prioritized over unknown and possible empty zones.

- Distance to built-up structures → Refugee population will likely settle closer to built-up areas where they have more chances to meet their basic needs such as food, water, work and school.

- Populated place density → The concentration of towns and villages also plays a significant role in the refugee population movements. By default, they will try to live with the rest of the population or with acquaintances who settled down years ago further to a previous humanitarian crisis. Same as built-up areas, populated places usually gather everything necessary to sustain a family (water points, food, schools...).

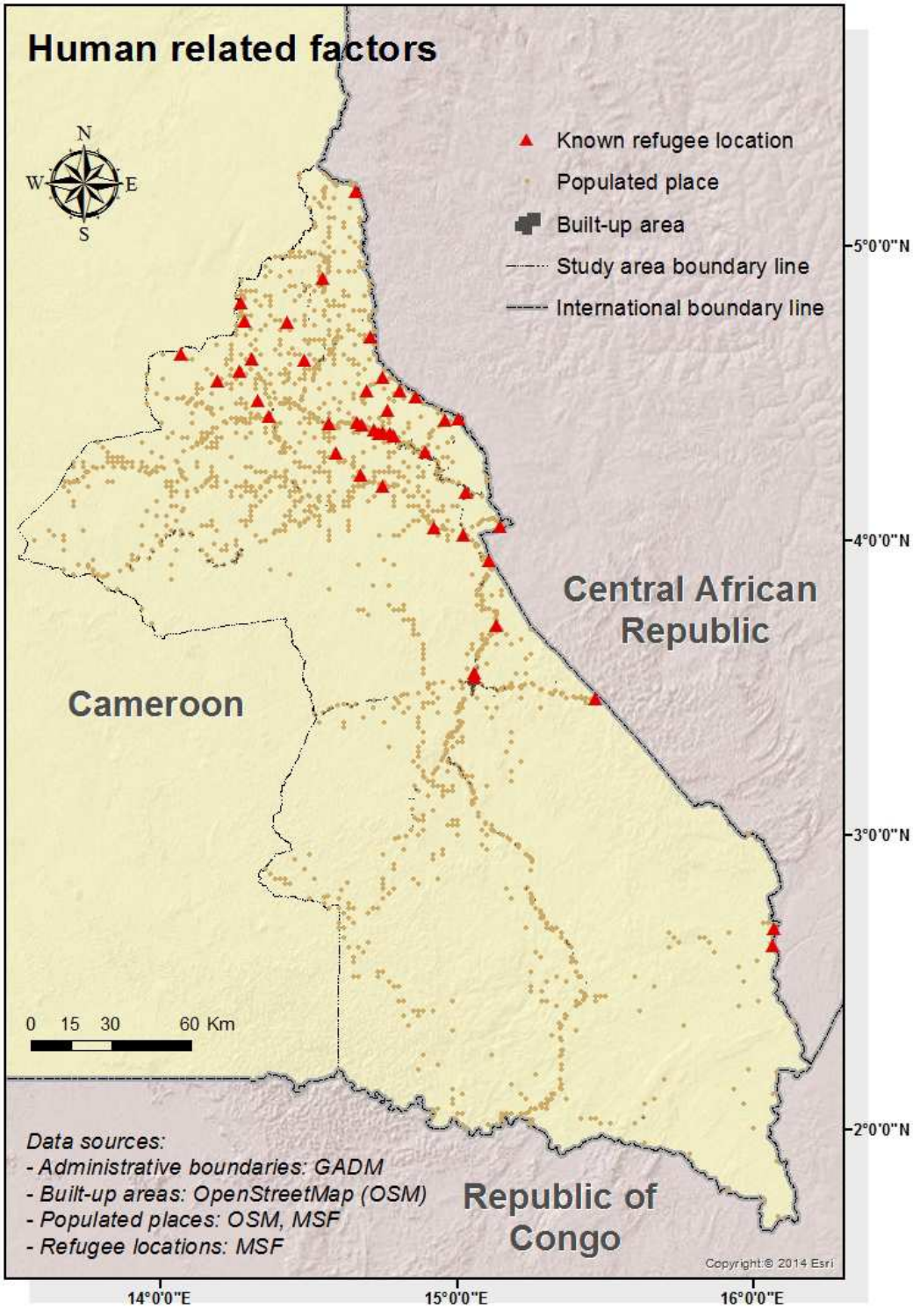

Figure 14: Human related factors (part 1)

- Distance to governmental health facilities → Whenever possible, MSF should focus its support in areas where primary health care access is not available or too far away. Unregistered refugees may be blocked by check points to reach these places or simply can't afford to travel long distances. Additionally, and unless the health centre need some support to handle a higher number of patients, it is recommended to mitigate medical activities overlap between MSF and existing governmental structures.

- Distance to other non-governmental health actors → Comparably to government health facilities, MSF should deploy mobile clinics where no other health actors can be found. In humanitarian contexts, overlaps sometimes happen due to a lack of communication between the different actors. This may cause problems such as a wrong use of resources (e.g. double distribution of therapeutic food) and can also lead to medical gaps in other areas. For this reason, it is essential to avoid areas where other health related NGOs work by ensuring a regular communication between actors.

  MSF also provides a significant support to the government hospital in Batouri and to the health centre in Gbiti. Therefore, mobile clinics should focus on different zones.

- Distance to official refugee camps → UNHCR refugee camps provide assistance to all registered refugees. It also offers guidance and support to any new refugee in the vicinity. Vulnerable refugee population is not usually situated right near official refugee camps. Therefore, MSF mobile clinics should cover other areas.

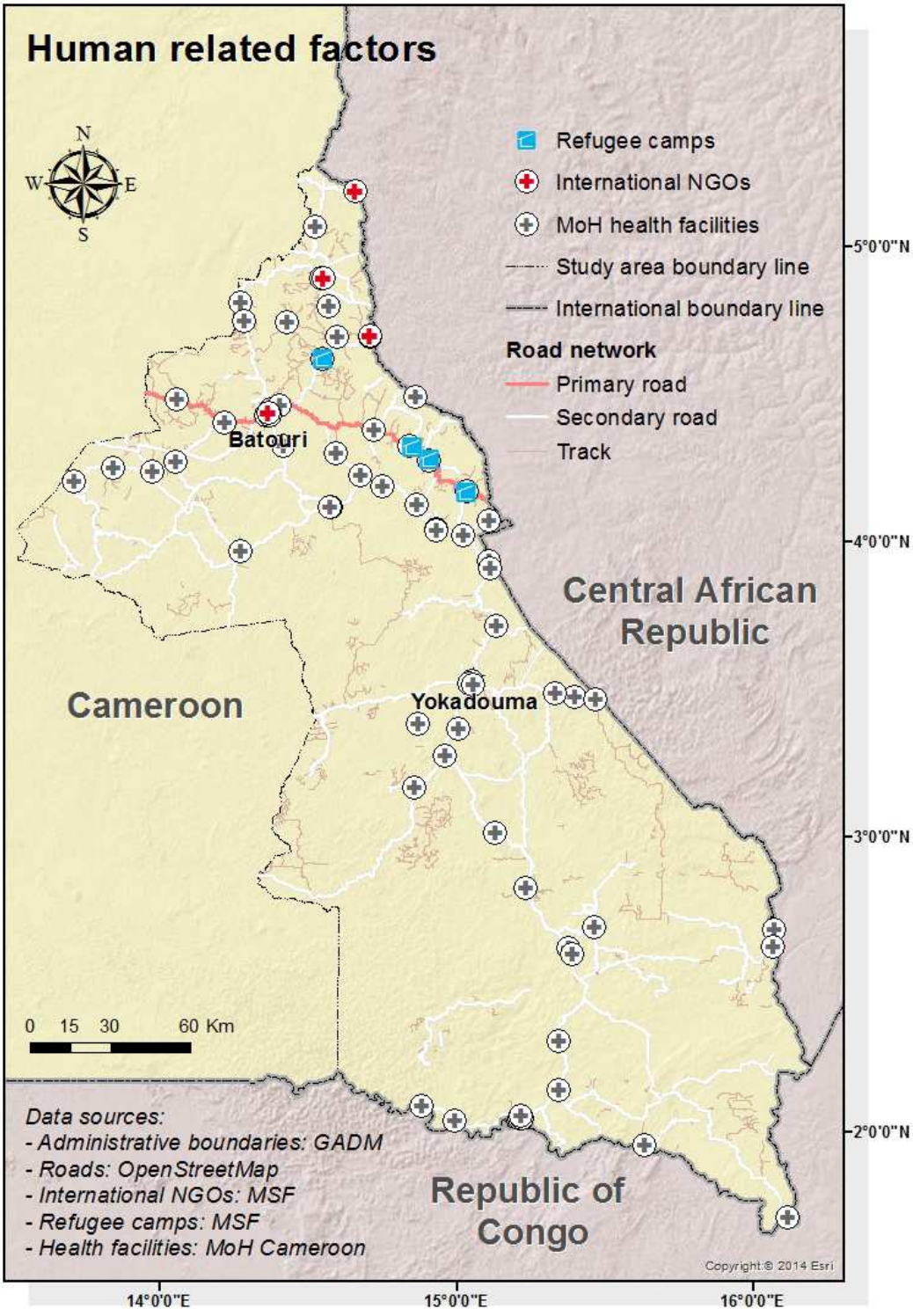

Figure 15: Human related factors (part 2)

3.5.3 Environmental Factors

This last class of factors are related to the land cover of the studied area. Refugee population would usually settle down in places based on the immediate surrounding land use (See Figure 16 and 17).

- Land cover → The type of vegetation will affect the population movements. Thick and dense forest will obviously be less attractive than grassland where refugees can bring their animal herds or agricultural areas where there might be work opportunity.

- Water course → The number of working water pumps being limited and unfit for an increase of population, the access to water is important. Population will try and leave nearby places where they can fetch water within walking distance.

- Protected areas → The south eastern part of Cameroon comprises forest reserves, wildlife reserves and national parks. These are official areas protected by the government where refugee population are not supposed to settle down. The use and access of resources in these areas are limited, if not forbidden, which makes the close surrounding inadequate for human habitat. The close vicinity of national parks or reserves may be used by local ethnic groups but would likely remain restricted and act as a barrier to ensure that parks are managed in a sustainable manner.

More factors could potentially influence the site suitability of mobile clinic activities but it is always challenging to obtain consistent and reliable data regarding a whole region. For example it would have been interesting to include illegal mining area, water source points or ethnical data provided that accurate information was available.

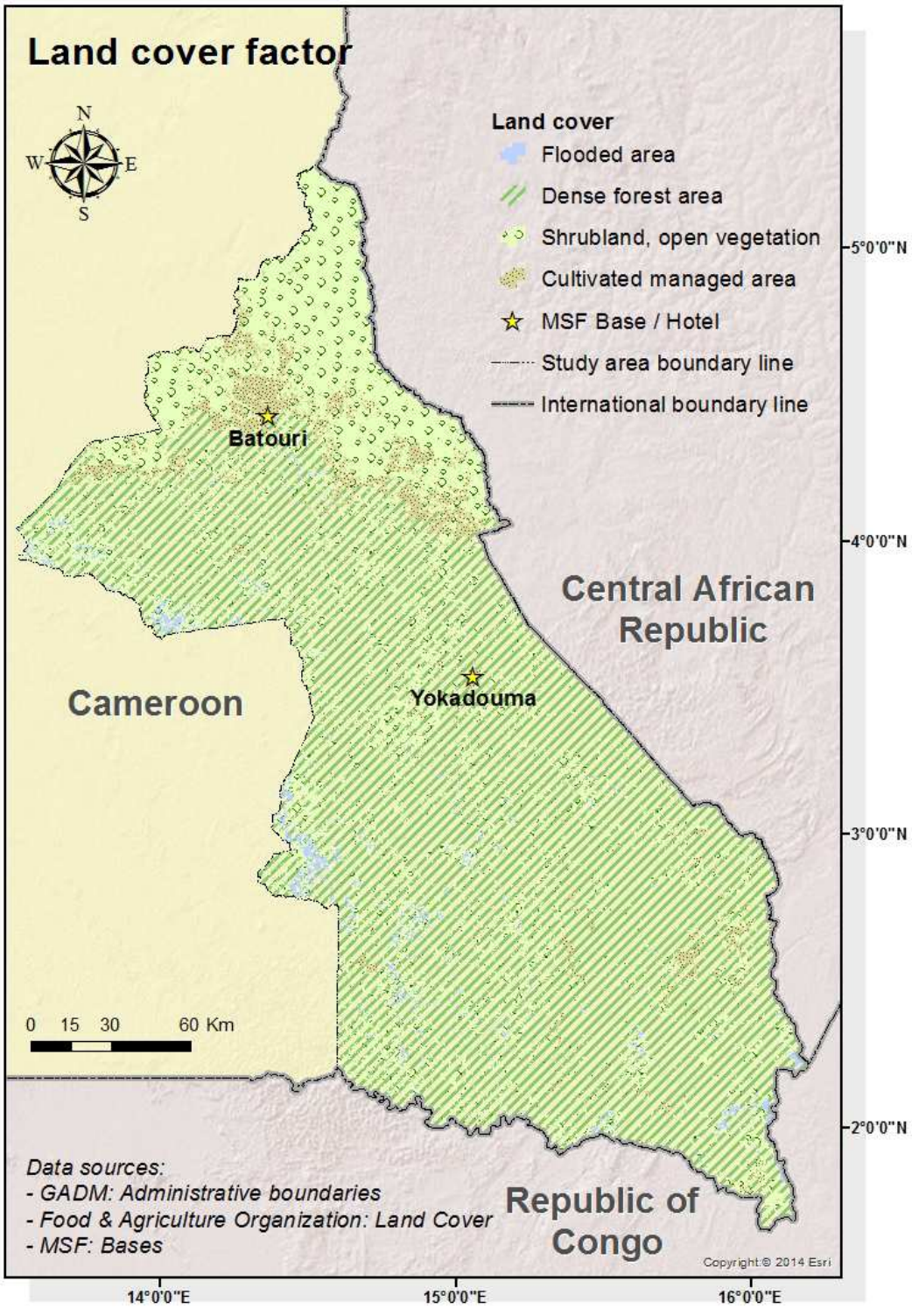

Figure 16: Land cover factor

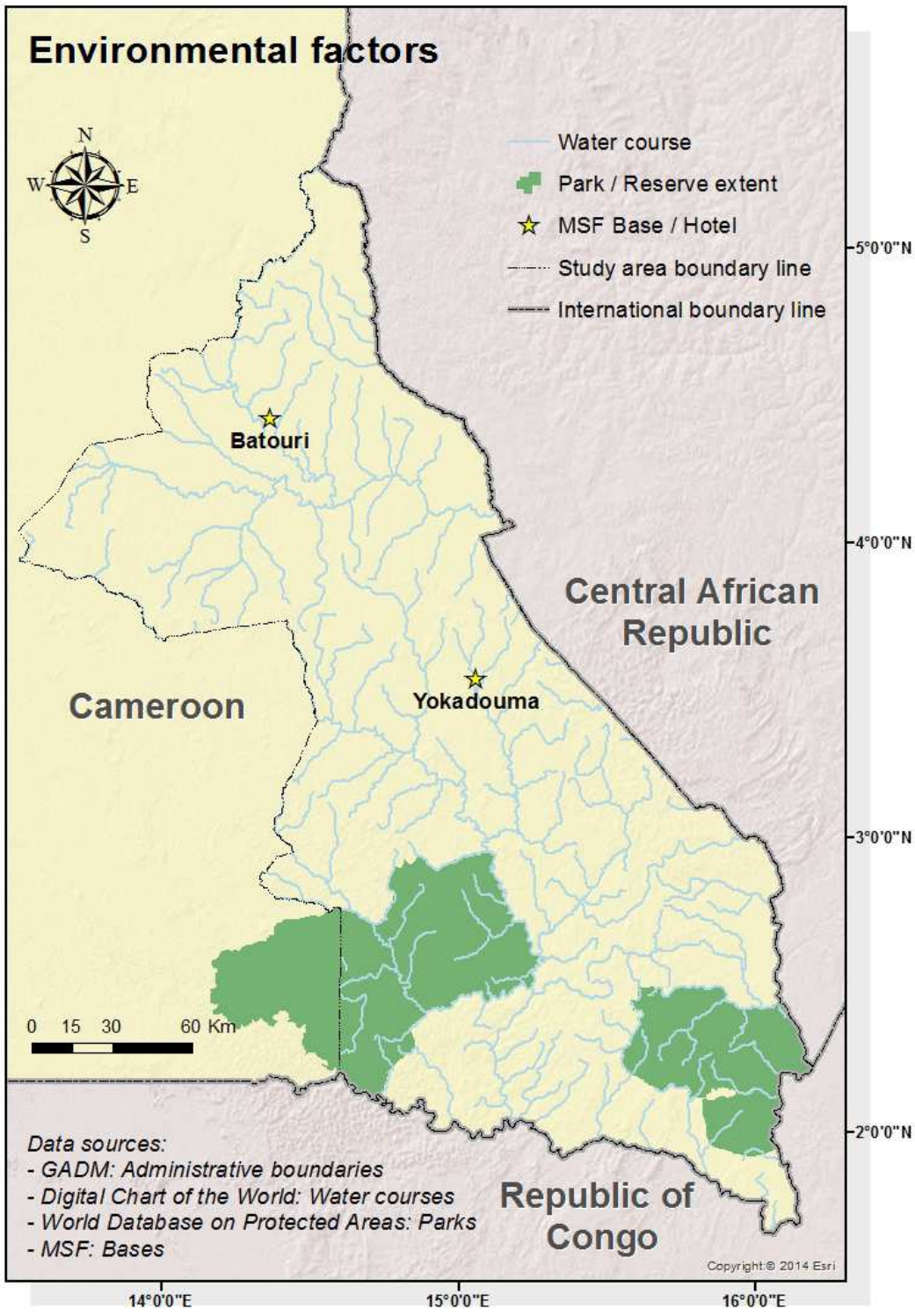

Figure 17: Environmental factors

3.6 Standardization of the Criteria

3.6.1 Classification Process

Once the criteria have been identified, the next step is their reclassification into a similar scale of values. In this project, the factors initially represented by vector layers (discreet geometrical objects: point, line and polygon) were transformed into raster layers (continuous surface) in which each cell represents an area of 100 x 100m (or 10 000 m^2).

Depending on the factor, the raster cells value can indicate:

- the distance (in meter) to the factor (e.g. distance to the MSF base)
- a density value (e.g. refugee population density)
- how attractive is the area for the refugees (e.g. land cover attraction)

Criteria classification is an essential part of the process. Decision makers can strongly influence the results depending on how they decide to categorize the data.
Classification of factor layers has always been one of the application-based parts of each AHP study. As mentioned before, one of the main advantages of AHP is that the knowledge of experts can be directly manipulated within the model and converted into valuable information. For example (Chaudhary et al., 2015) applied AHP for suitable fire site selection over four different criteria with a classification of their factors based on their own expert opinion. (Uyan, 2013) used GIS and AHP to determine suitable sites for solar farms. Five criteria were considered in two groups (environmental factors and economic factors) before being reclassified based on decision makers expertise. Standardization of criteria was also an important process in an analysis aiming to identify appropriate landfill site locations (Khan and Samadder, 2015). They mentioned the classification of the 11 criteria in a table and stated that the application was based on experts' opinion and knowledge.

On the other hand, one of the main disadvantages of AHP is the subjectivity that is associated with these opinions of experts (Nefeslioglu et al., 2013). Different judgments of values will affect the weights assigned to the criteria which may alter the results to some extent (Mishra et al., 2015). With this in mind, it is essential to consider the

inputs from the different team members so that the classification illustrates the best compromise.

In this project, the data were classified based on strategic discussions which took place during the mission in Cameroon (See Table 3). The logic behind the classification of the considered factors comes from initial field assessments and proposals made by experienced MSF employees after consultation with the MSF coordination team and headquarters. To facilitate the discussions between the MSF field experts team, the MSF coordination and headquarters, an internal strategic MSF report was produced based on the facts collected during the field assessment (MSF-CH, 2014e). These internal debates at different MSF levels together with all the information collected led to opening the outreach health activities according to the Batouri mission project document (MSF-CH, 2014a).

However, due to the high volatility of the context, the working strategy kept evolving to meet the reality of the field (e.g. no mobile clinic at the border). Such decisions were made during field coordination meetings and involved the head of departments (logistics managers, medical managers, field coordinator, mobile clinic focal point, etc.) as well as the input of knowledgeable local staff. After a few weeks in the field, the MSF field supervisors could establish certain rules on where to run mobile clinic activities as we had a better overview of our boundaries. Experience from previous missions was also an asset to support the logic behind the reclassification of each factor (see Section 3.2).

Different value intervals in the standardization modify the resulting maps but it would have a limited impact on the edges (least or most suitable areas) unless experts were to have a radically different judgment about one or more factors. However, the MSF working method always involves a group decision making process where the team members are welcome to bring their own inputs and experiences to enrich the discussion. The selection of the criteria and their influence make no exception.

The factors reclassification system is strongly based on MSF strategic group discussions and MSF expert opinions. This includes my own experience as I was compiling their knowledge and converting the logic of our decisions into numerical values during classification.
In addition to expert knowledge, a trial-and-error approach was carried out to ensure that the application had its optimal results given the values and intervals selected.

Based on table 3, 13 site suitability maps (1 per factor) are generated using ArcGIS.
Values from 1 (least suitable) to 5 (most suitable) are automatically assigned to each cell of the maps.

CLASS	FACTOR	#	RECLASSIFICATION				
			1	2	3	4	5
Security related	Distance from MSF base (km)	C1	>110	90-110	70-90	50-70	0-50
	Distance from International border (km)	C2	0-0,5	0,5-1	1-4	4-8	>8
	Distance from Entry points (km)	C3	0-1	>40	1-3	3-10	10-40
	Distance from Roads (m)	C4	>1000	600-1000	400-600	200-400	0-200
Human related	Refugee locations density	C5	Low =======> Medium =======> High				
	Distance from MoH health facilities (km)	C6	0-1	1-2	2-5	5-8	>8
	Distance from Built-up areas (km)	C7	>20	10-20	5-10	2-5	0-2
	Distance from International NGOs (km)	C8	0-2	2-4	4-9	9-18	>18
	Distance from Refugee camps (km)	C9	0-1	1-3	3-6	6-12	>12
	Populated places density	C10	Low =======> Medium =======> High				
Environmental	Land cover attraction	C11	Low =======> Medium =======> High				
	Distance from Water courses (km)	C12	>4	3-4	2-3	1-2	0-1
	Distance from Protected areas (km)	C13	<0	0-5	5-10	10-20	>20

Table 3: Factors reclassification

The figures 18 to 43 show the map of each criterion together with its respective function after reclassification.

3.6.2 Security/Safety related Factors

C1: Distance from MSF Base

During the strategy discussions, the MSF field team considered that working closer from the MSF base is considered more suitable for mobile clinic activities:

- The travel time is reduced therefore there is a much lower risk of accident.
- The team must be back to the base before dark. The risk to be back after dark is highly increased when working far away (less unexpected situations on the road).
- The team can be gathered more quickly in the MSF base in case of a security situation.
- Additionally, less time spent travelling results in more time spent treating patients. Following the field assessments during the first days after arrival (MSF-CH, 2014a), the logistics team leader noticed that it would take one hour to travel 50km (in average). Given this information, one of the farthest places where the team agreed to run a mobile clinic is situated 110km away from the base and due to the long time spent travelling, it was decided to not exceed this distance. Based on this information, an interval every 20km was used for the reclassification (see Figures 18 and 19).

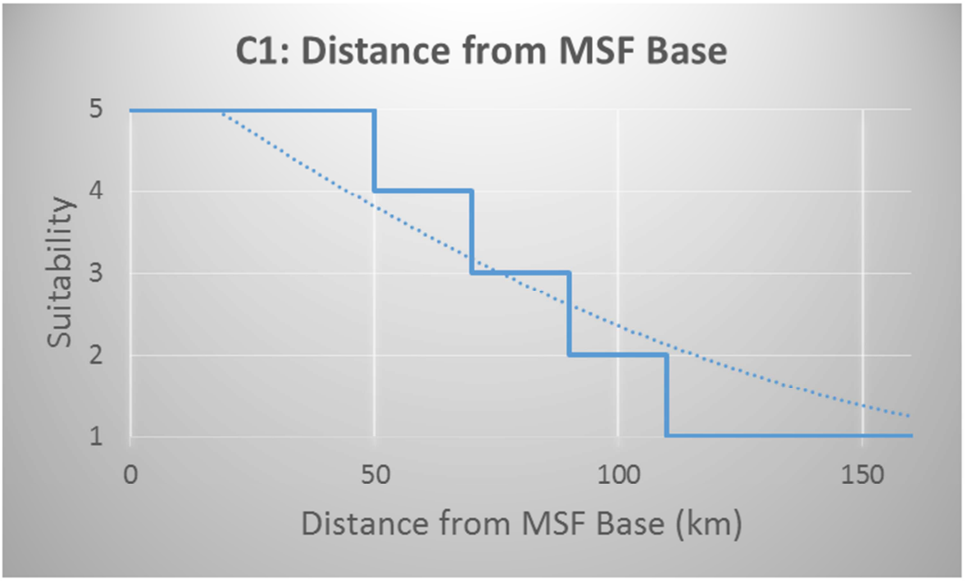

Figure 18: Suitability graph (factor 1)

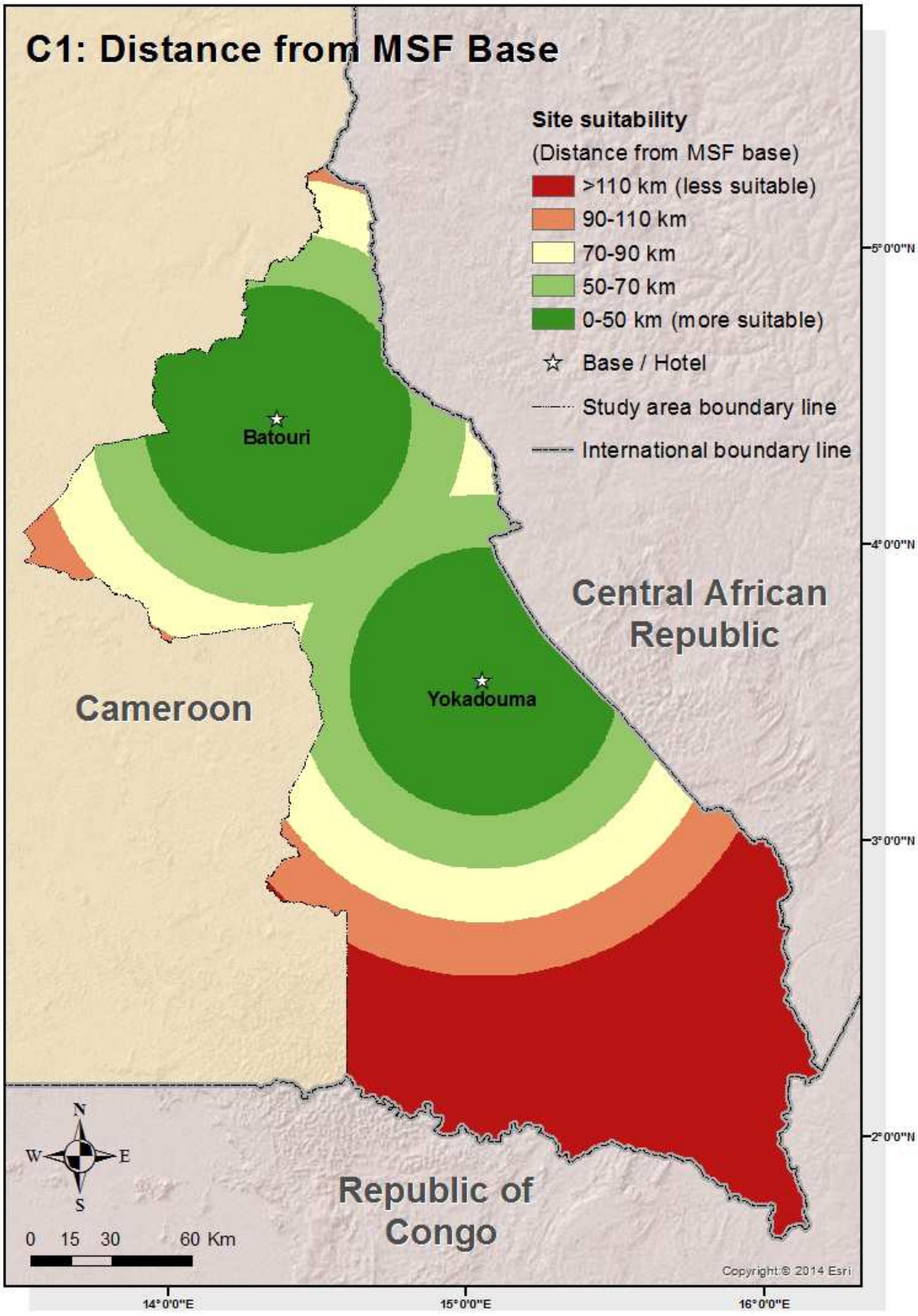

Figure 19: Distance from MSF base (Euclidean distance)

C2: Distance from International Border

Most of the security incidents and rebel attacks took place near the Central African Republic border. On several occasions, shooting occurred right near the border (within 500m). Closer we are to this boundary line and higher is the risk to be targeted directly or indirectly by a rebel group crossing illegally the border for a short period of time. Therefore MSF decided that the mobile clinic should remain at a certain distance. In such a context, it is rather complex to determine how far inside Cameroon a rebel group may enter. However during daytime they would not penetrate far due to the presence of the local authorities.

It is reasonable to say that the very close vicinity with the border is to be avoided (below 1km) whereas a 4km distance (one hour walk) can be considered as suitable and 8km as very suitable (see Figures 20 and 21).

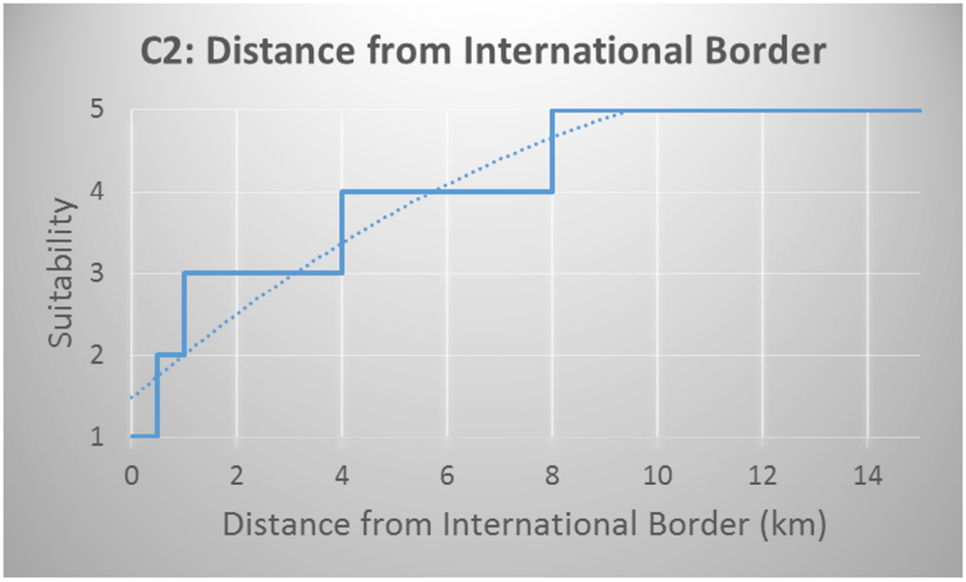

Figure 20: Suitability graph (factor 2)

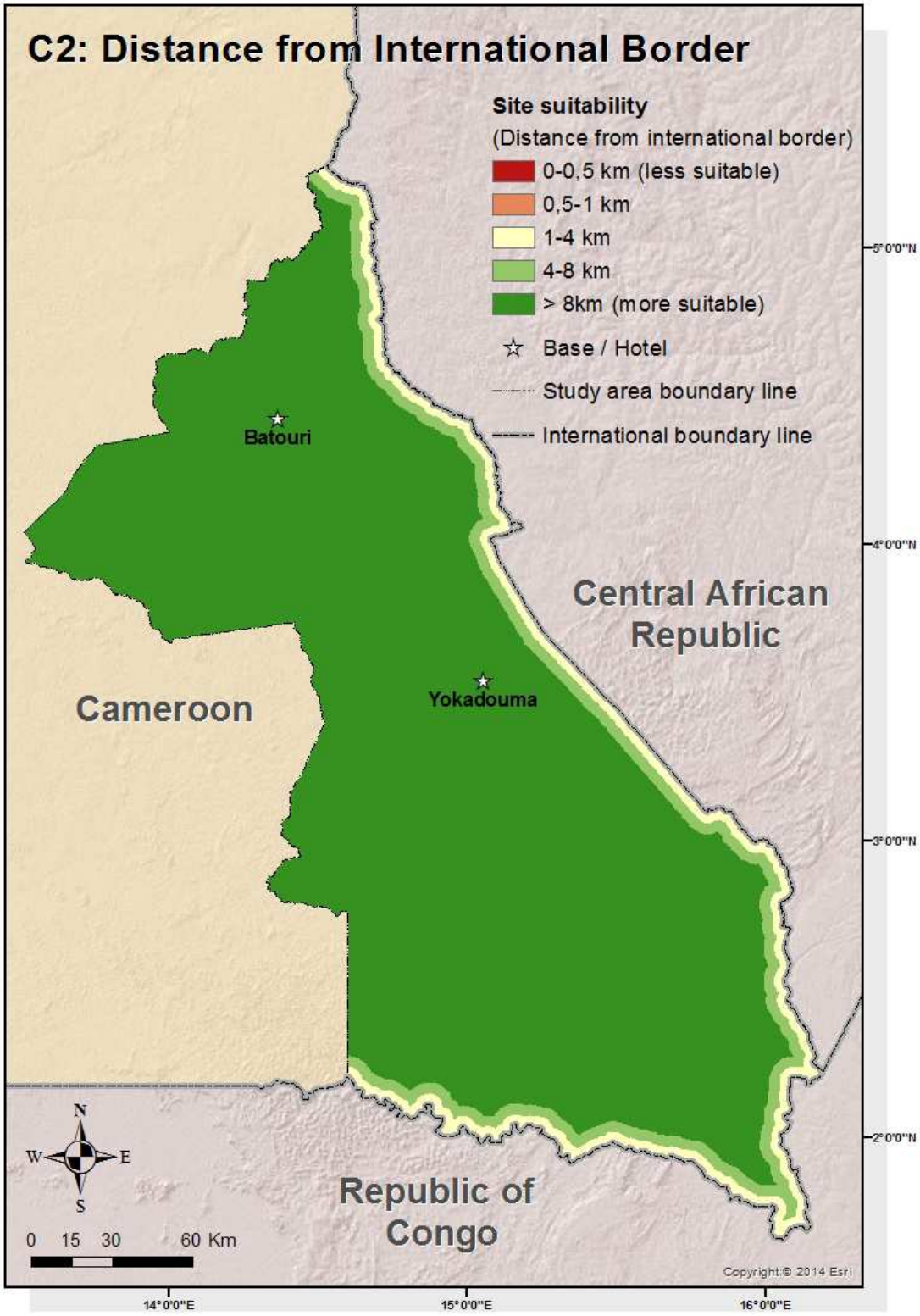

Figure 21: Distance from international border (Euclidean distance)

C3: Distance from Entry Points

As with the previous factor (C2), the proximity with the refugee entry points is sensitive in terms of security. It is not recommended for the MSF team to work right at the entry points knowing the risks of rebel incursions. For the same reasons, refugees won't usually settle down too close from the entry points. Therefore it makes more sense to keep a certain distance.
However, they will not move too far away either. After weeks of travels, they are exhausted, they are usually in bad health, they hope to meet with some relatives travelling the same routes and unless they are officially recognized as refugees by the United Nations they cannot easily pass the military checkpoints in Cameroon.

The buffers 3 to 40km are identified as the most suitable ranges for mobile clinic activities. The sites located within 3km from the border have a higher insecurity. Over 40km from the border it is unlikely to find refugee settlements due to distance and checkpoints (see Figures 22 and 23).

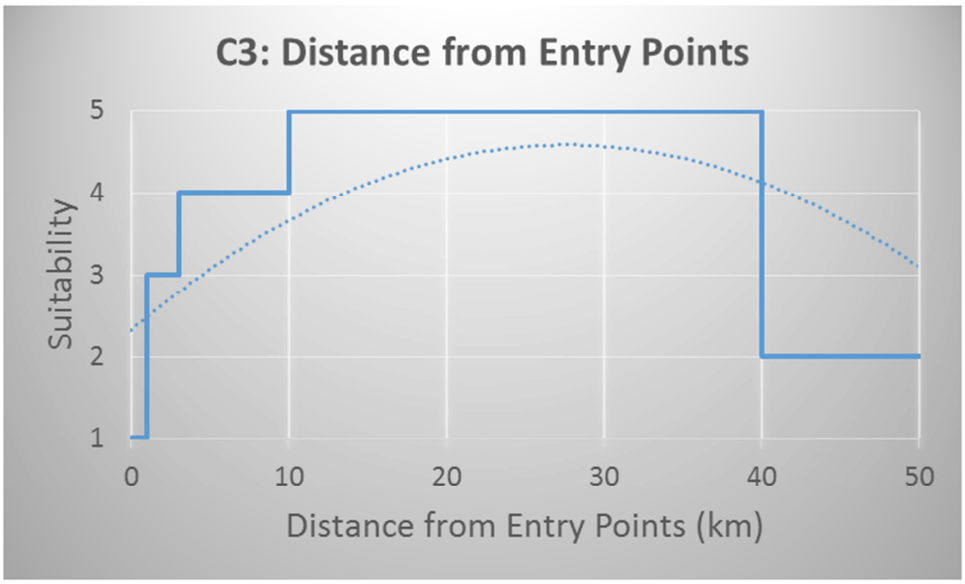

Figure 22: Suitability graph (factor 3)

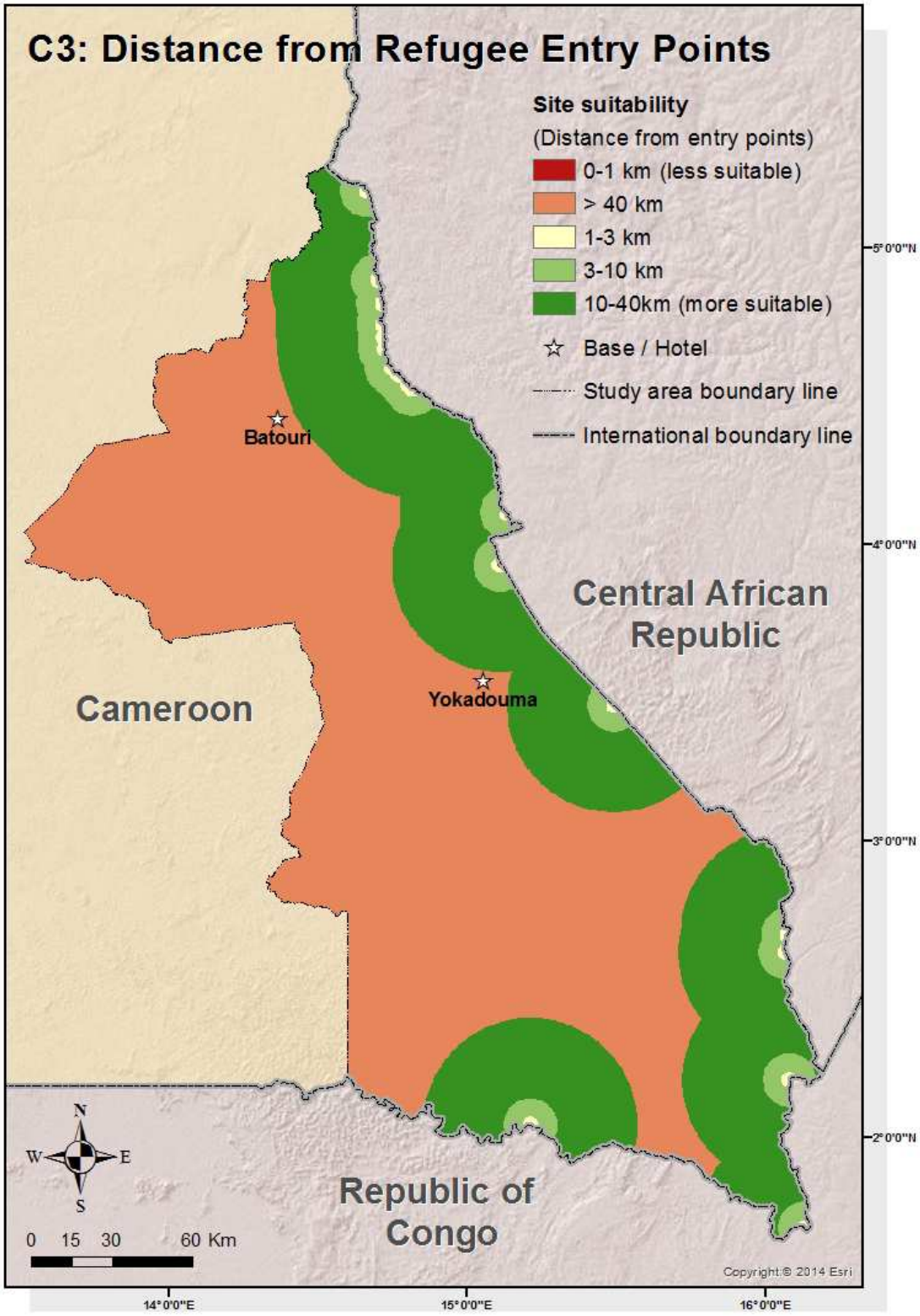

Figure 23: Distance from refugee entry points (Euclidean distance)

C4: Distance from Roads

Given the security context at the time of the MSF deployment, it was decided to set up the mobile clinics near a decent access to the main roads (see Figures 24 and 25). The main reason is to ensure a regular radio contact between the team and the MSF base (through the car radio). It is important to know where all the team members are situated at any given moment. In case of an evacuation, the staff should be able to reach their car quickly. Driving off-road should be avoided and working next to the cars would be ideal.

However this criterion may evolve if one or more new refugee pockets are found away from the roads. This criterion is not the most important in terms of influence but it may still play a significant role in the event the context changes. In this case, the classification will need to be adapted to the reality of the field.

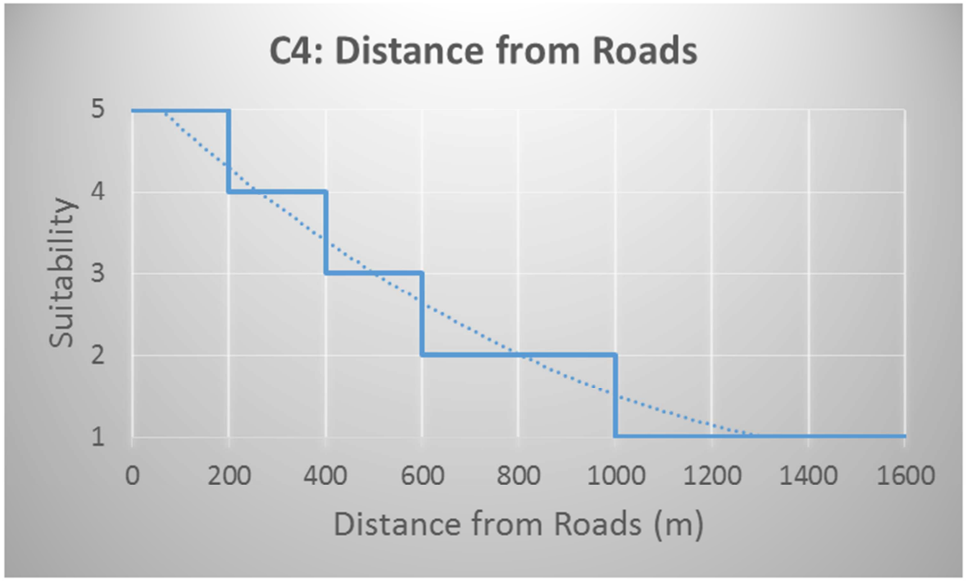

Figure 24: Suitability graph (factor 4)

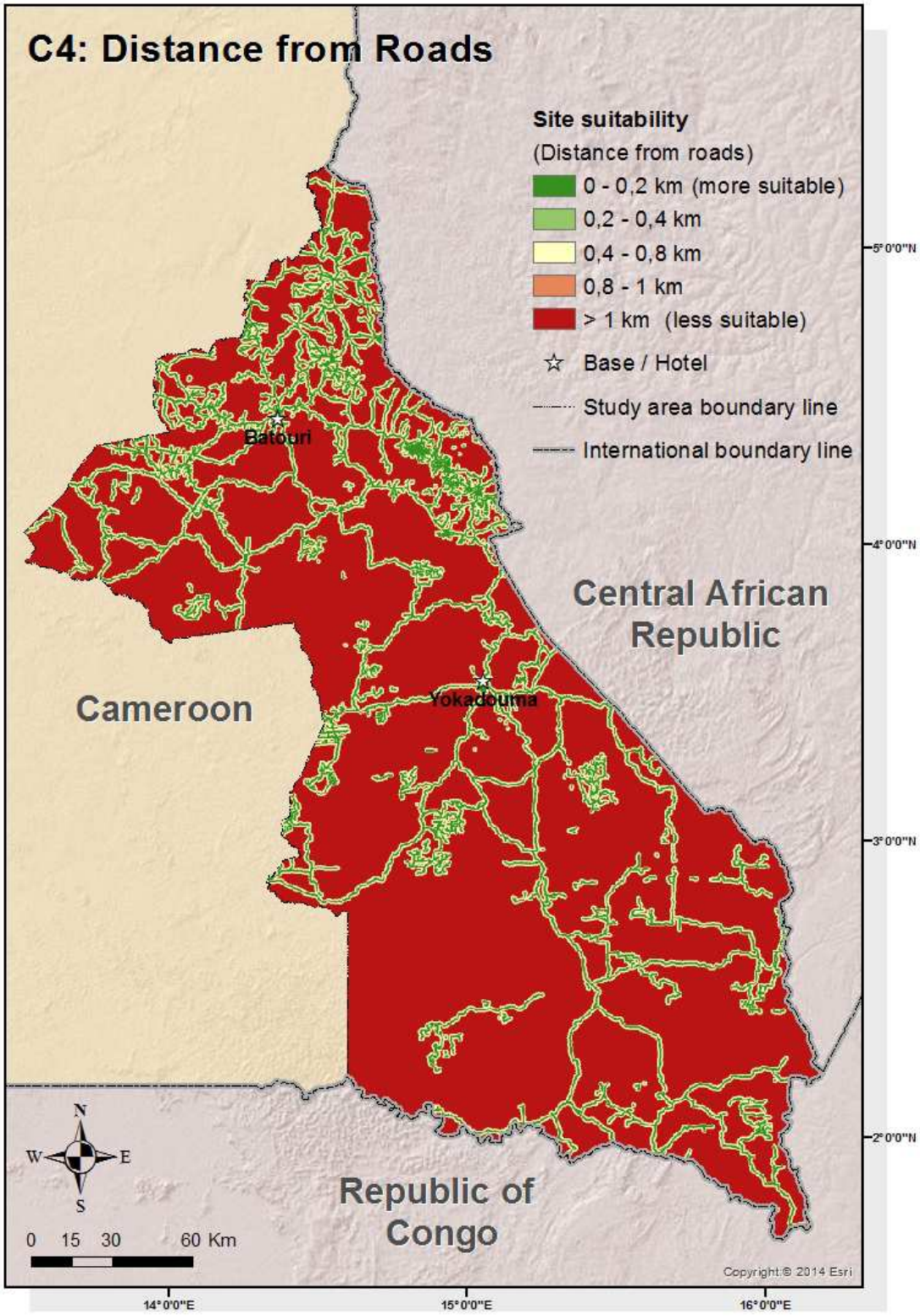

Figure 25: Distance from roads (Euclidean distance)

3.6.3 Human related Factors

C5: Refugee Population Density

This is probably one of the most important factors. The priority of MSF is to reach the vulnerable refugee population therefore we should work where they can be found.
This layer represents the places where refugee pockets were discovered by MSF during the field assessments. The refugee population density has been generated from the point density algorithm (ArcGIS) based on the number of refugees per known locations.
Obviously, MSF should prioritize locations where refugees were found during the assessment (unofficial camps, scattered families, etc.). Mobile clinic activities should focus on these sites. However, some places are known to have many more refugees than others and this difference should also be considered in the analysis. Areas with a high density of refugees are more suitable whereas areas with a very low density of refugee will be much less suitable (see Figures 26 and 27).

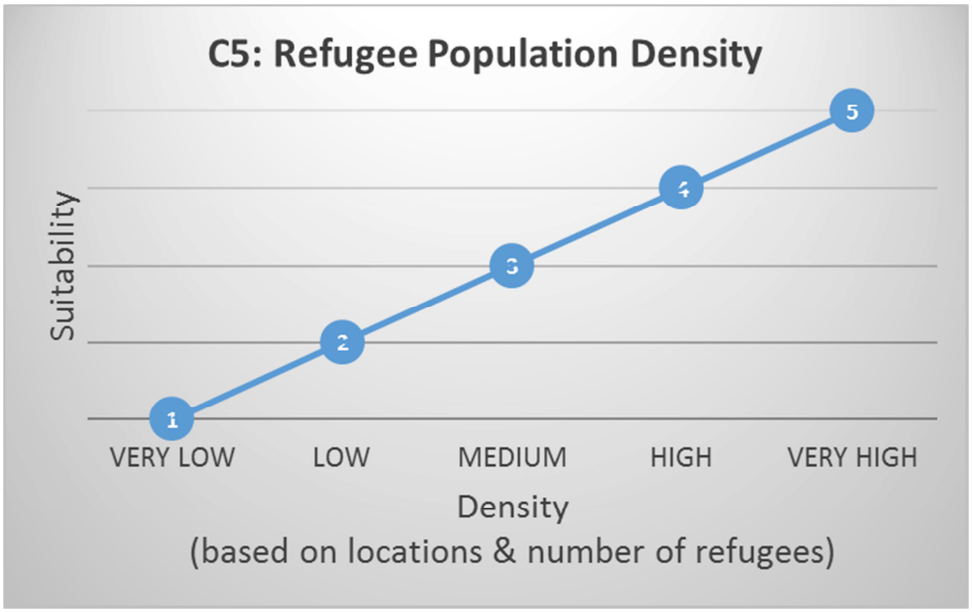

Figure 26: Suitability graph (factor 5)

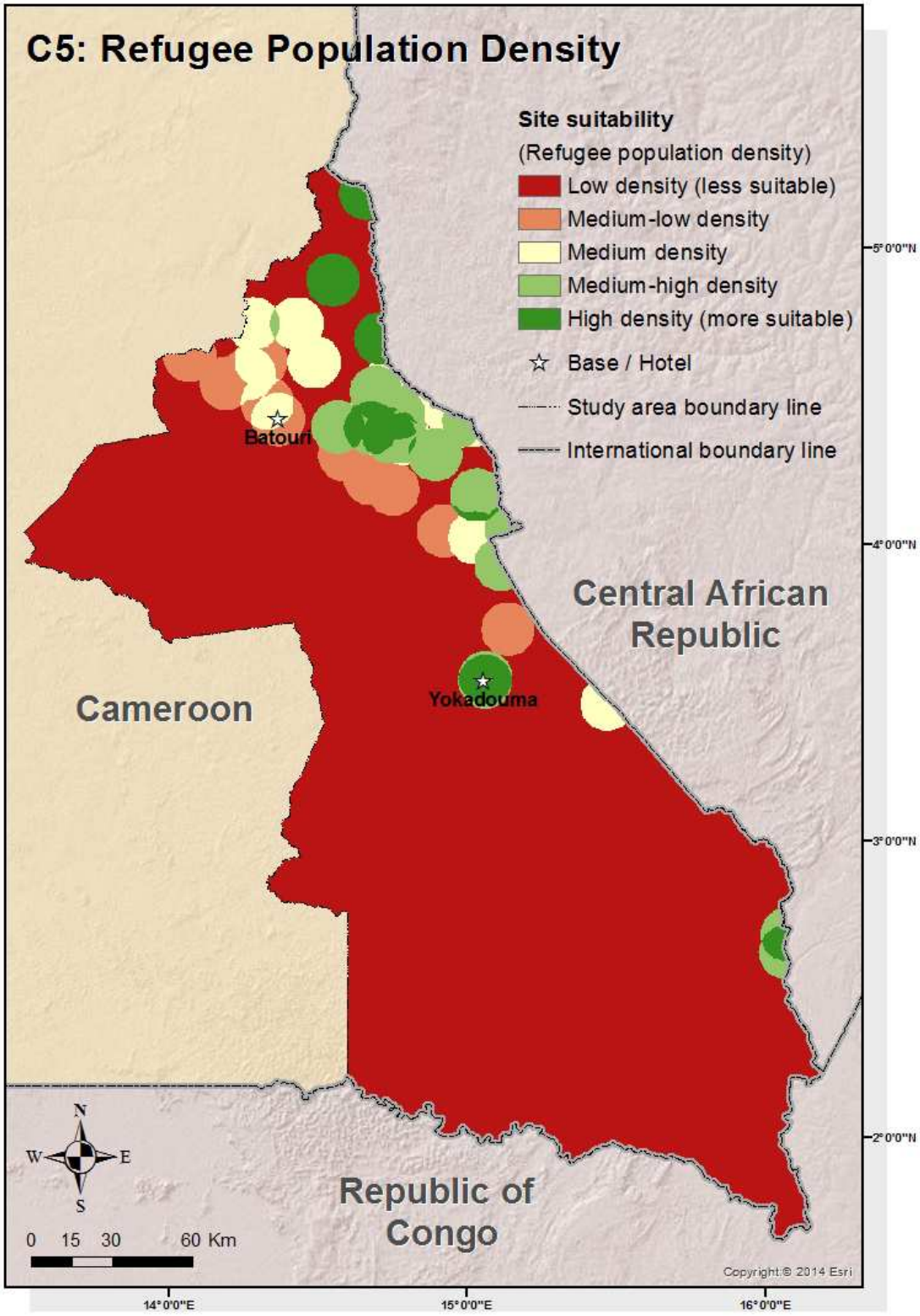

Figure 27: Refugee population (Point density)

C6: Distance from MoH Health Facilities

Following a physically/mentally extremely difficult displacement, refugees will tend to stay around places where they can get access to their basic needs. Access to health care is one of them. In reality, refugees will stay in areas where they are allowed to by the local communities. Sometimes this can be far away from the governmental health centres. MSF should bring more support to refugees that cannot have access to health care or can't afford travelling all the way to the health centre.

In addition, the organization does not want to overlap with the health centres activities so it is better to cover areas that are remote to these medical centres.

A very low suitability is given to any area below 1km from a health centre whereas a very high suitability is assigned to areas over 8km (about 2 hours by foot).

See Figures 28 and 29.

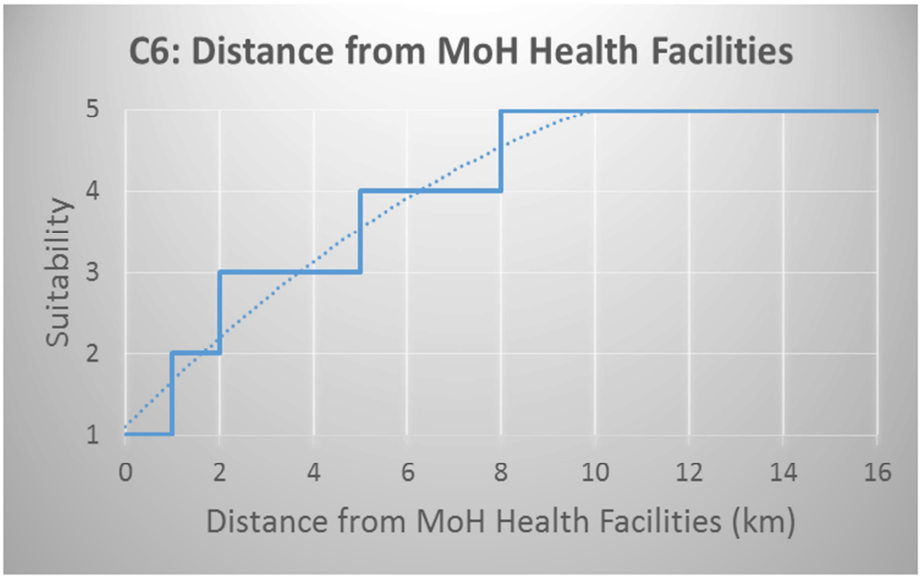

Figure 28: Suitability graph (factor 6)

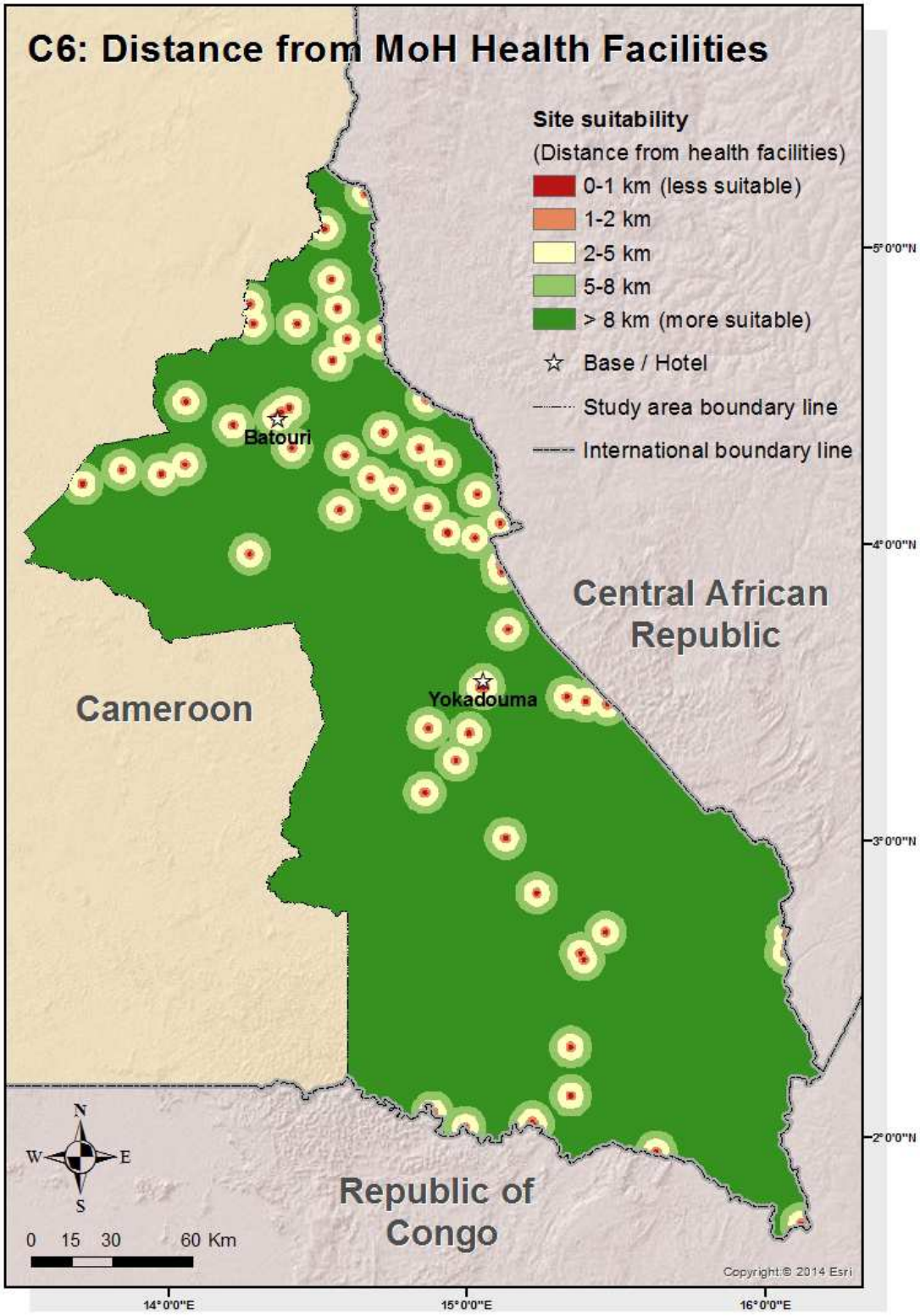

Figure 29: Distance from MoH health facilities (Euclidean distance)

C7: Distance from Built-up Areas

Refugees will more likely settle down near built-up areas where there is a human activity. They may want to join members of their family that fled to Cameroon in one of the previous humanitarian crises. They will also try to find a place to live, to work, or a school for their children.

It is unlikely to find refugees more than 20km from any populated area. Most of the refugees met by the field assessment teams were located in the close vicinity of existing villages or near shelters or huts. Therefore areas located near the built-up structures are considered as highly suitable whereas areas situated far away are unsuitable (see Figures 30 and 31).

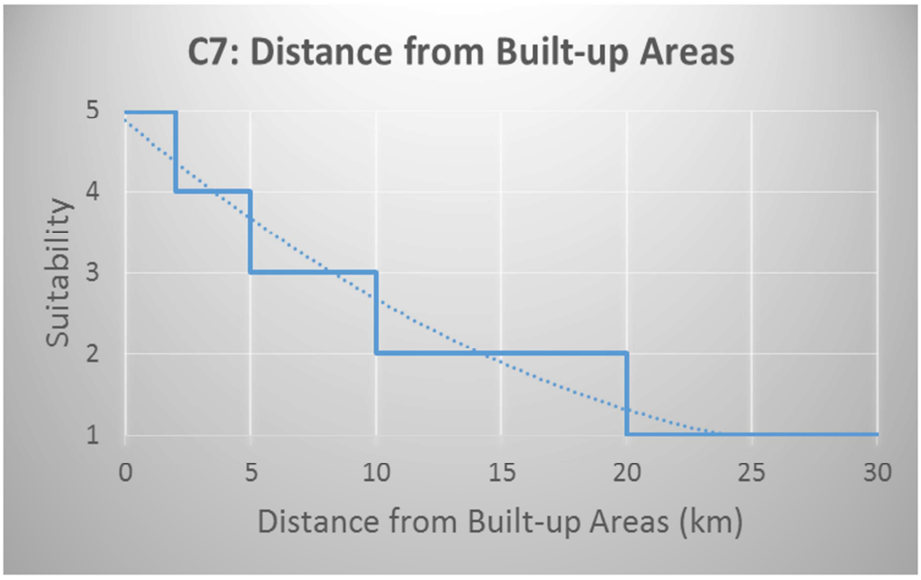

Figure 30: Suitability graph (factor 7)

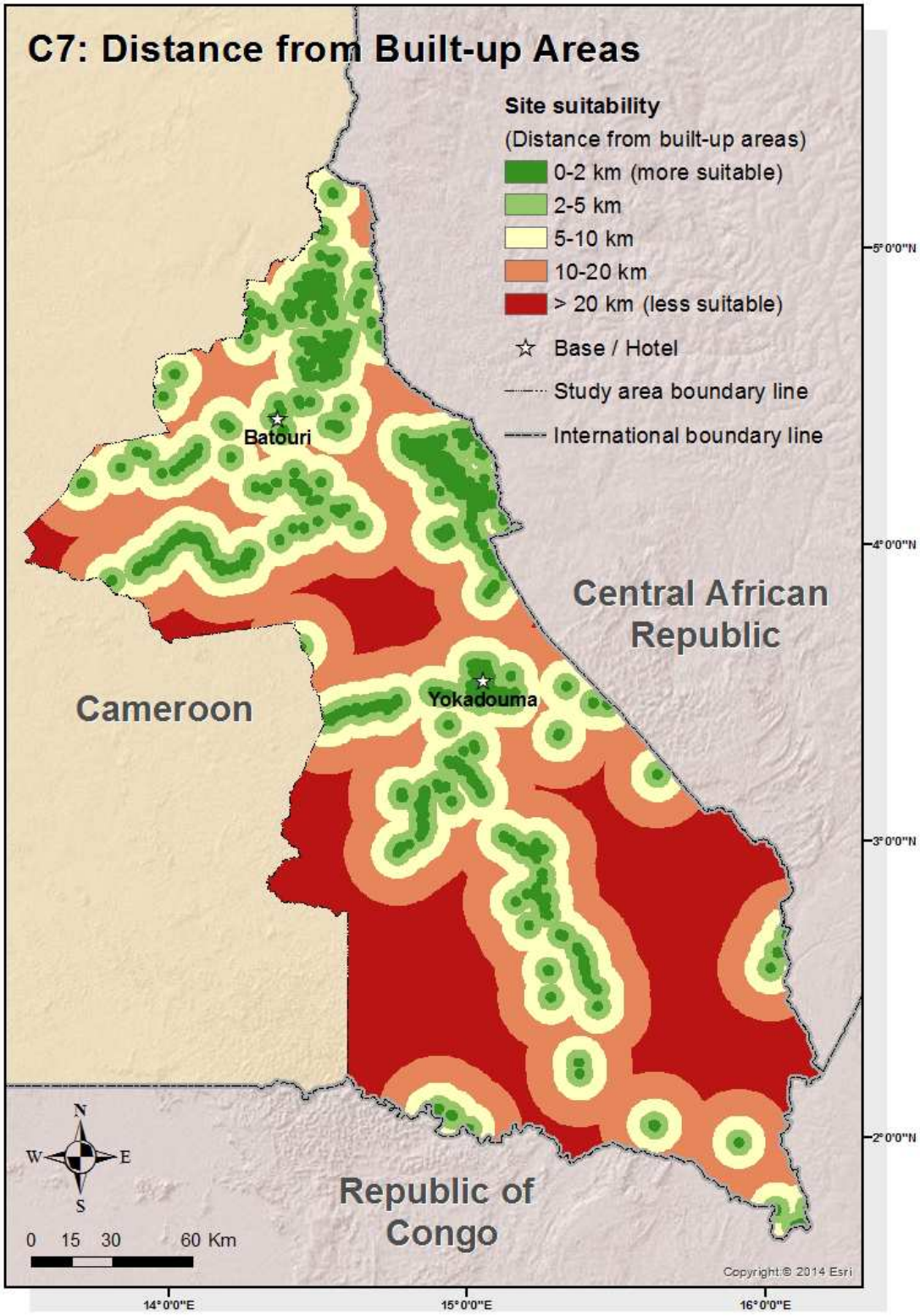

Figure 31: Distance from built-up areas (Euclidean distance)

C8: Distance from International NGOs

This layer highlights international health NGOs locations whether it is another existing MSF project (Gbiti, Batouri) or another NGO (e.g. the Red Cross).

The objective is to avoid any overlap with other health projects. MSF will focus on areas where there is no other significant health support (such as the Red Cross). There is also no point to run mobile clinics where MSF already gives a full support to the Ministry of Health structures (Gbiti and Batouri).

International NGOs usually have a reliable supply system to answer emergency crises. They offer a totally free health care and often have health promotions activities to inform the vulnerable population in the area. Therefore they will tend to have a larger geographical influence than governmental facilities (criteria 6).

For this reason, the classification is slightly different. An area will be considered as very unsuitable for mobile clinics in a 0 to 2km buffer zone whereas it will be highly suitable over 18km (See Figures 32 and 33). Other intervals are 4km and 9km.

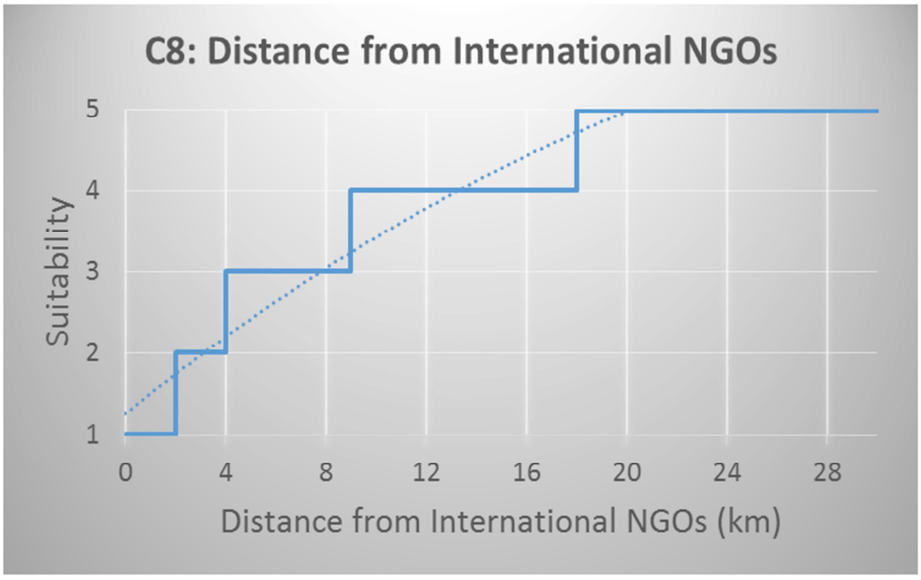

Figure 32: Suitability graph (factor 8)

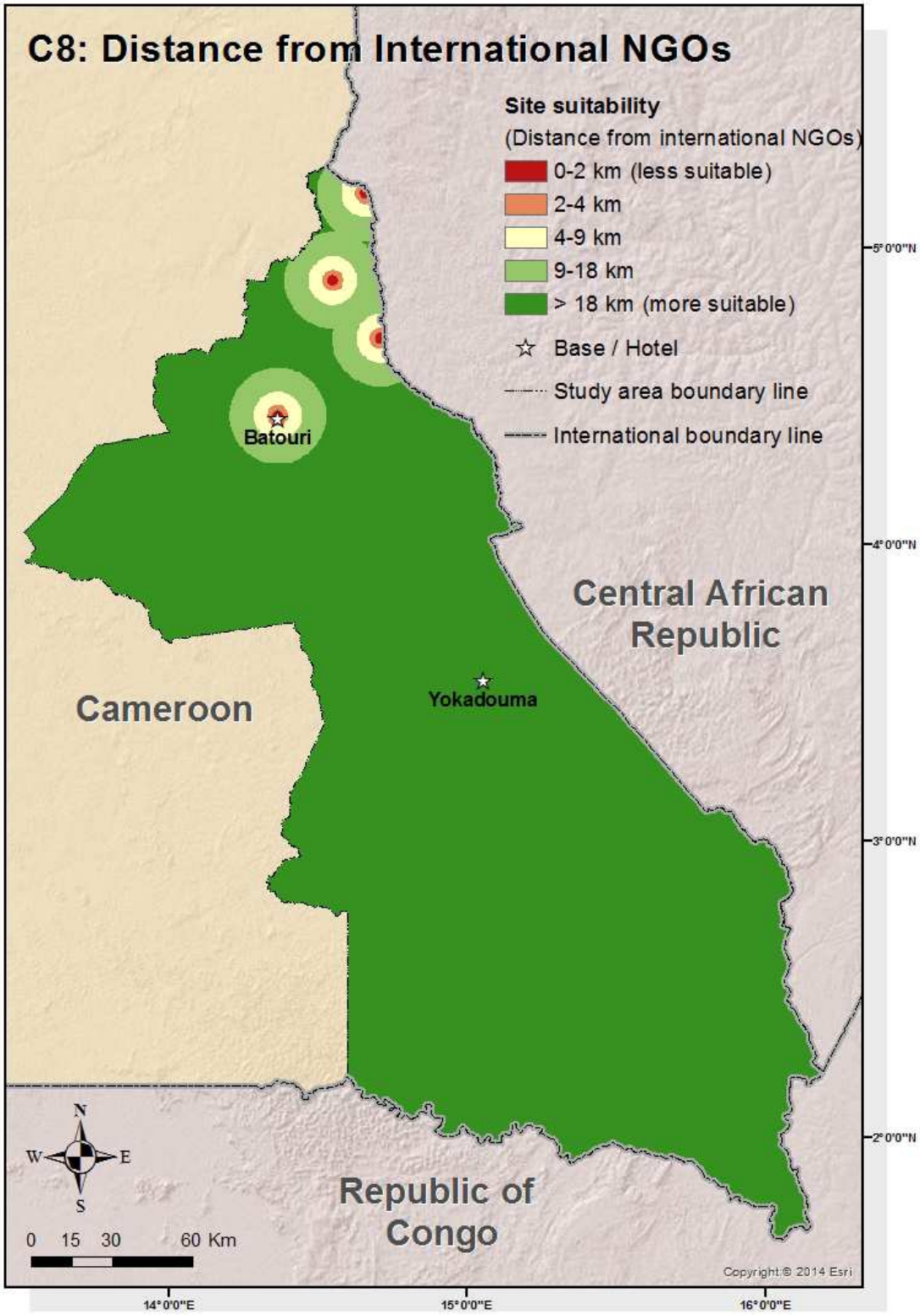

Figure 33: Distance from international NGOs (Euclidean distance)

C9: Distance from Refugee Camps

Same as with the international NGOs criterion, it is important to avoid working too close from the official refugee camps. UNHCR camps include free health care for registered refugees so it does not make much sense to open additional health activities right outside the camps. However, based on field experience in this region, their influence on the surrounding communities is more limited than the international health NGOs. Therefore the values intervals were classified slightly differently. An area situated within 1km of a camp is classified as very unsuitable whereas an area situated over 12km (2-3 hours walk) is classified as highly suitable (value 5). Other intervals are 3km and 6km (see Figures 34 and 35).

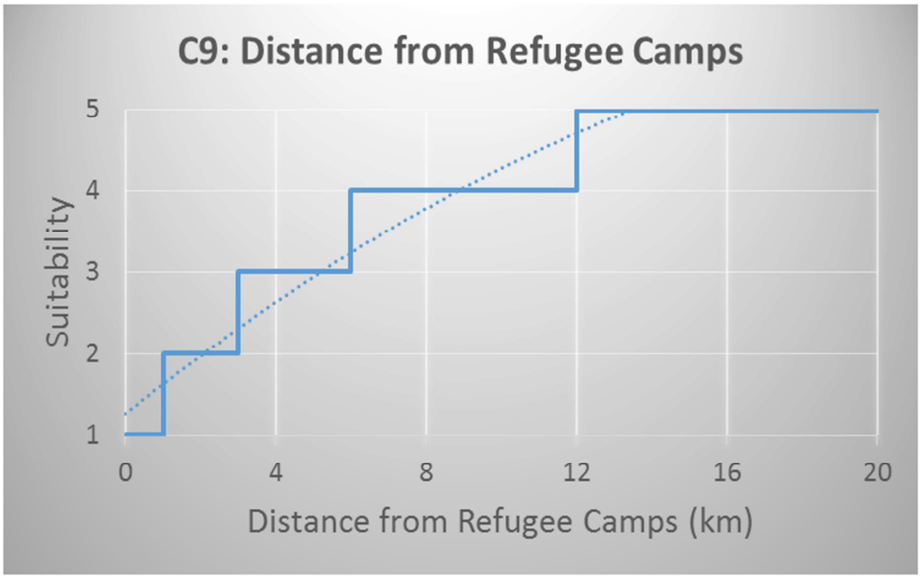

Figure 34: Suitability graph (factor 9)

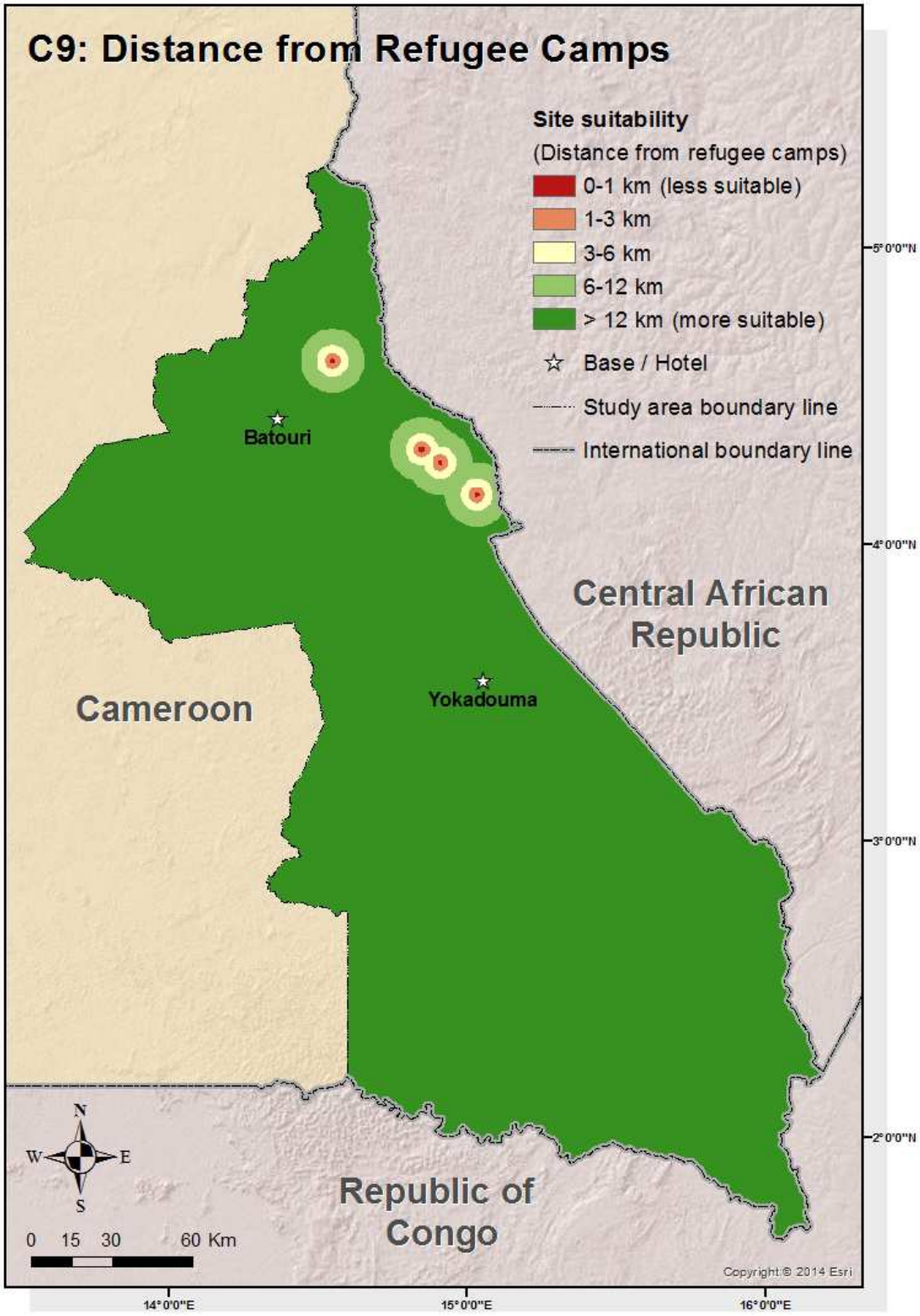

Figure 35: Distance from refugee camps (Euclidean distance)

C10: Populated Places Density

The influence of populated places is quite similar to the one of built-up areas. Refugees will very likely settle down in or near populated places where they can find food, water, material, school and potential work opportunities.

This factor has been reclassified according to the density of populated places in the study area (see Figures 36 and 37). An area is considered as very suitable if the density of populated places is high and unsuitable if the density is low. Three classes were used as this factor does not have such a high influence in the analysis (compared to the refugee population density).

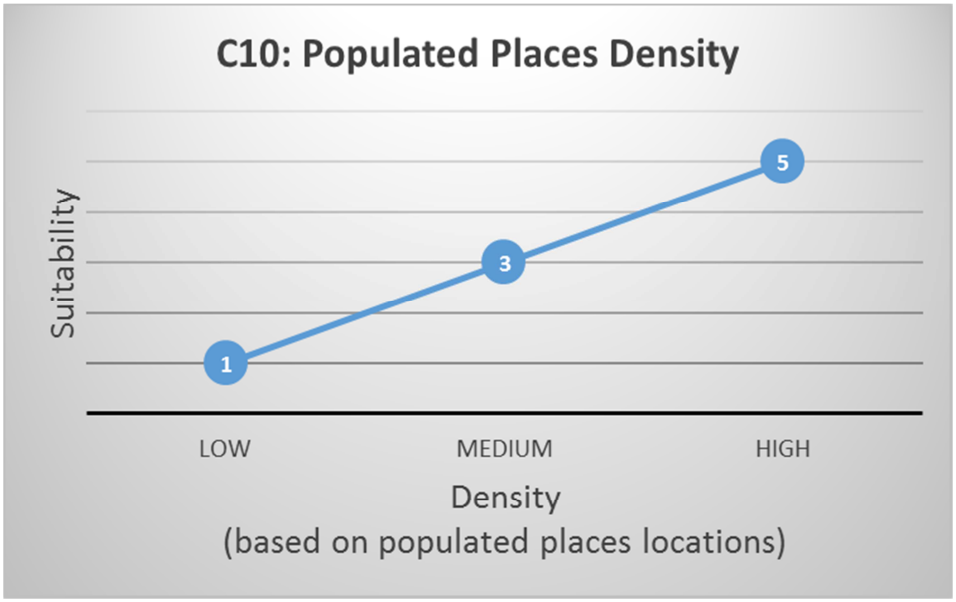

Figure 36: Suitability graph (factor 10)

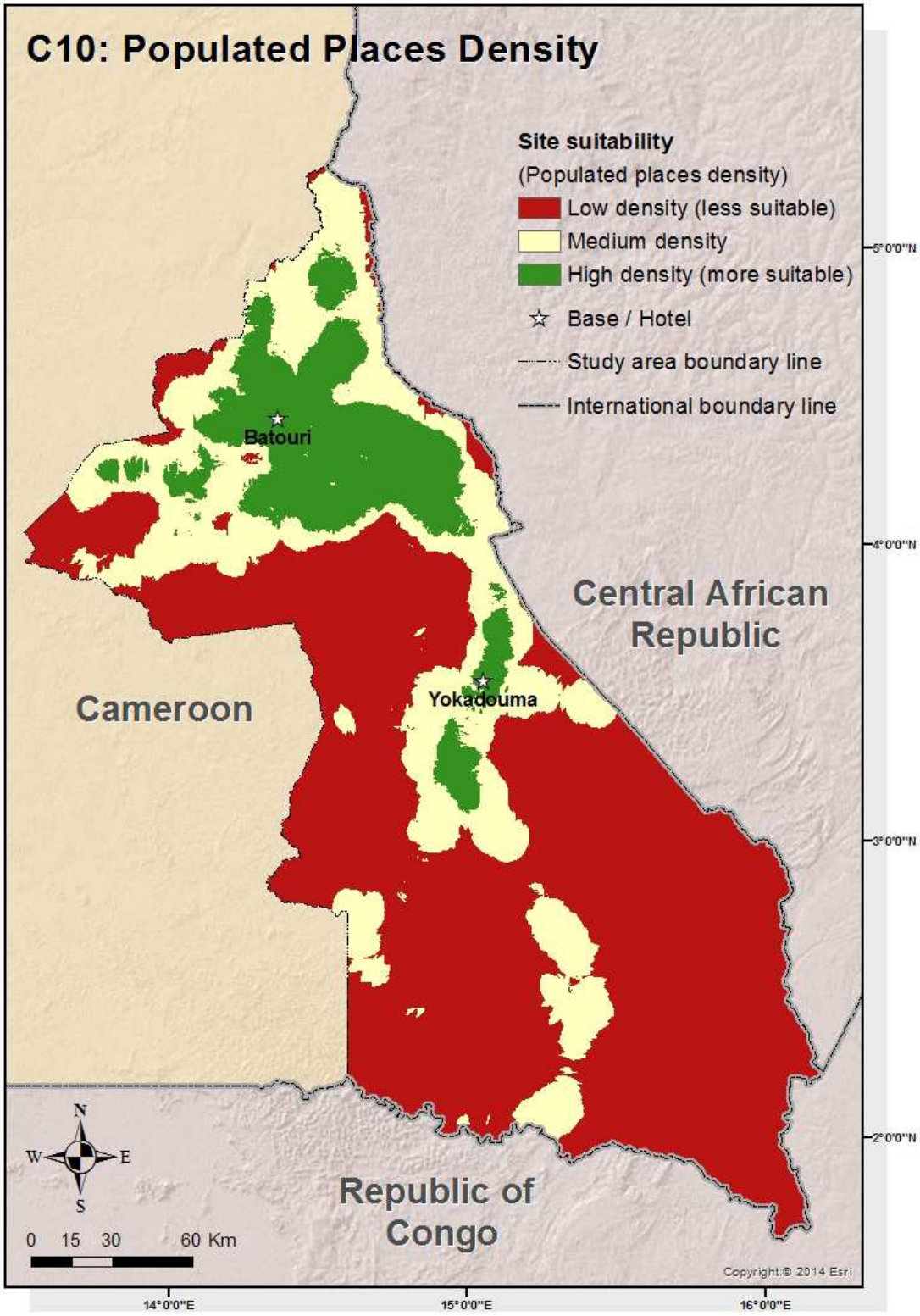

Figure 37: Populated places (Point density)

3.6.4 Environmental Factors

C11: Land Cover Attraction

Most of the study area is covered by thick rain forest with poor or no infrastructure at all. This type of land cover is not attractive for the refugees. They will usually try to settle down near agricultural lands (managed areas) or open lands where they can try and find work opportunities, food or even bring their herds (some refugees are herders and managed to cross the border with their herd).

Open and cultivated lands will be classified as highly suitable (more chances to find refugees) whereas thick forest or water bodies will be classified in the lower suitability ranges (see Figures 38 and 39).

The level of attraction (see Table 4) is based on this hypothesis. This trend could also be confirmed in the field when meeting and discussing with refugee community leaders.

Land Cover label (source: FAO)	Estimated Attraction for Refugees
Cultivated and managed terrestrial area(s)	5
Natural And semi-natural primarily terrestrial vegetation	4
Closed to open trees (40-10)%: broadleaved evergreen trees, semi-deciduous trees, shrub land, woodland, herbaceous vegetation	3
Closed to open trees (100-40)%: broadleaved evergreen trees, semi-deciduous trees, shrub land	2
Artificial water bodies, natural water bodies, permanently flooded lands	1

Table 4: Land cover reclassification (level of attraction for refugees)

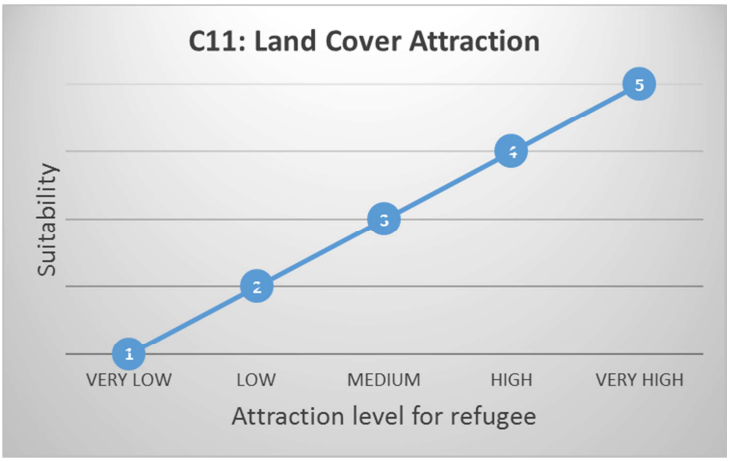

Figure 38: Suitability graph (factor 11)

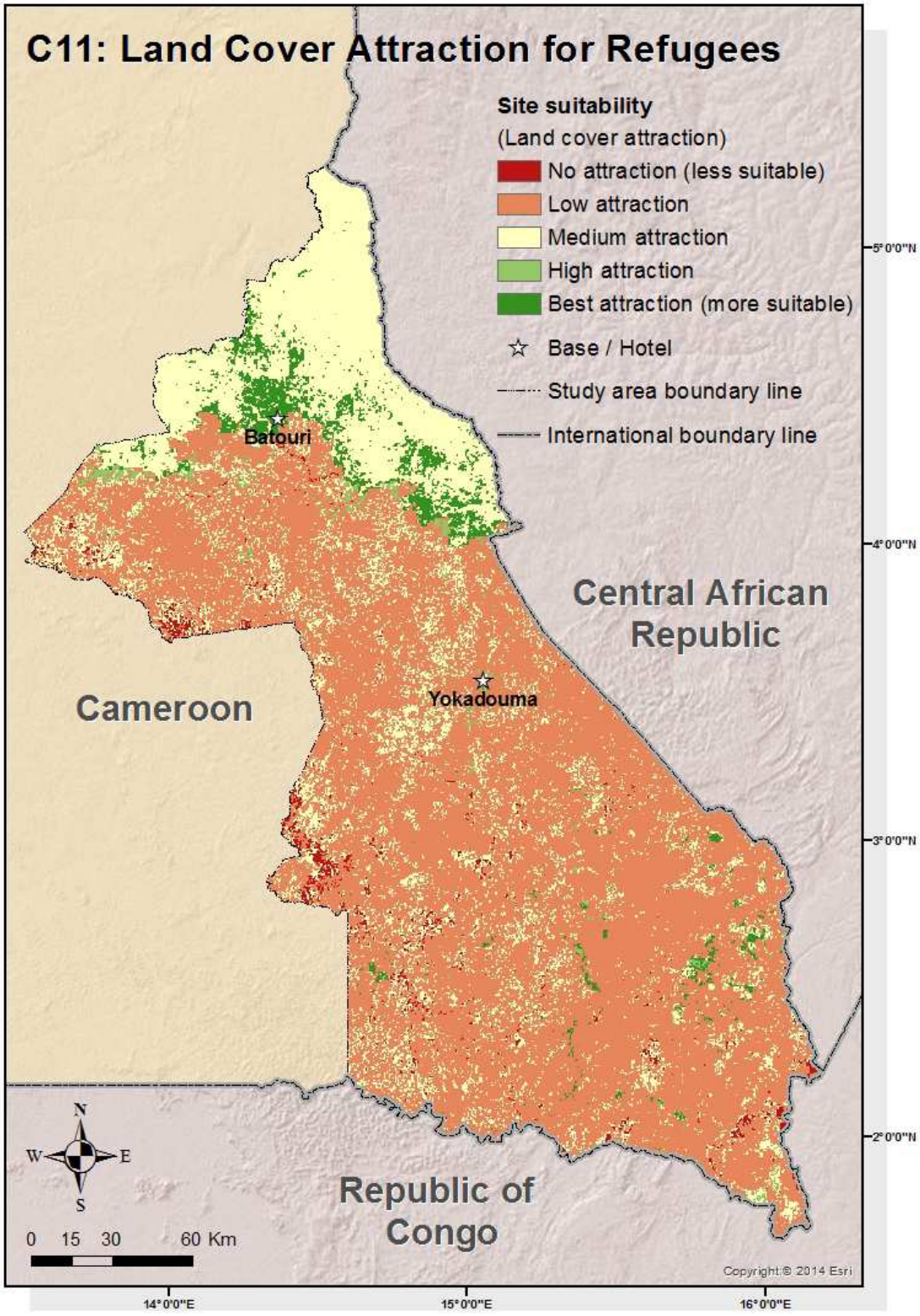

Figure 39: Land cover attraction for refugee

C12: Distance from Water Courses

Water is a precious resource and a basic need. Working water points and wells are very limited, even for the Cameroonian population. Refugees will tend to settle down close to water courses where they can get access to water. Areas within 1km from a water course have been classified as very suitable whereas areas farther than 4km (about 1 hour on foot) are classified as very unsuitable. Other intervals are 2km and 3km (see Figures 40 and 41). This factor has a limited priority but it may still have some influence. Field discussions with communities showed that access to water is one of the primary concerns.

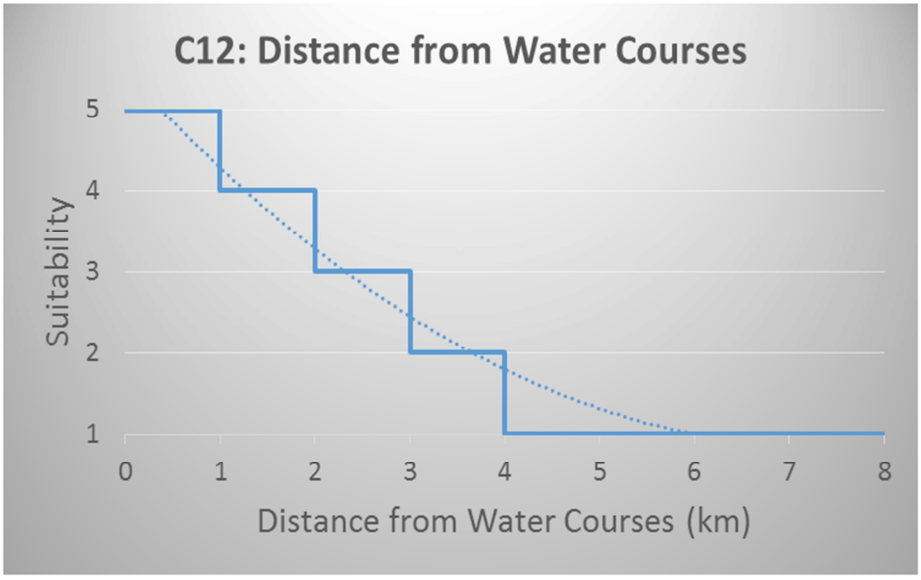

Figure 40: Suitability graph (factor 12)

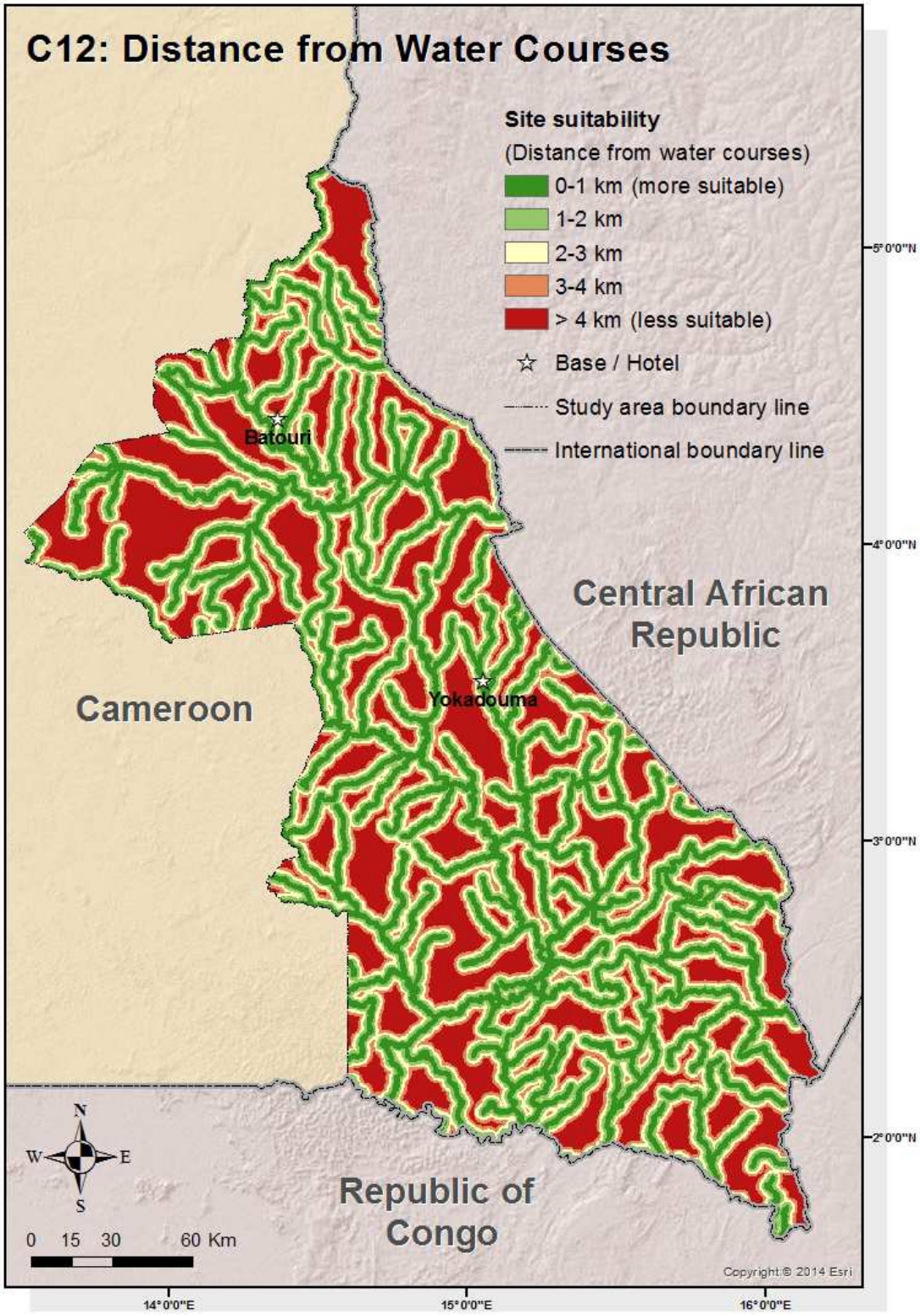

Figure 41: Distance to water course (Euclidean distance)

C13: Distance from Protected Areas

Finally, it is very unlikely to find refugees inside or near the boundaries of protected areas such as national parks or reserves. Natural resources in these areas are controlled by authorities who will want to avoid any increase of existing poaching or illegal logging activities. Due to the unconfirmed exact position of the boundaries, buffer zones have been utilized in the analysis. Areas inside the protected areas are obviously very unsuitable whereas areas over a 20km buffer zone are classified as very suitable. Intermediate intervals are 5km and 10km (see Figures 42 and 43).

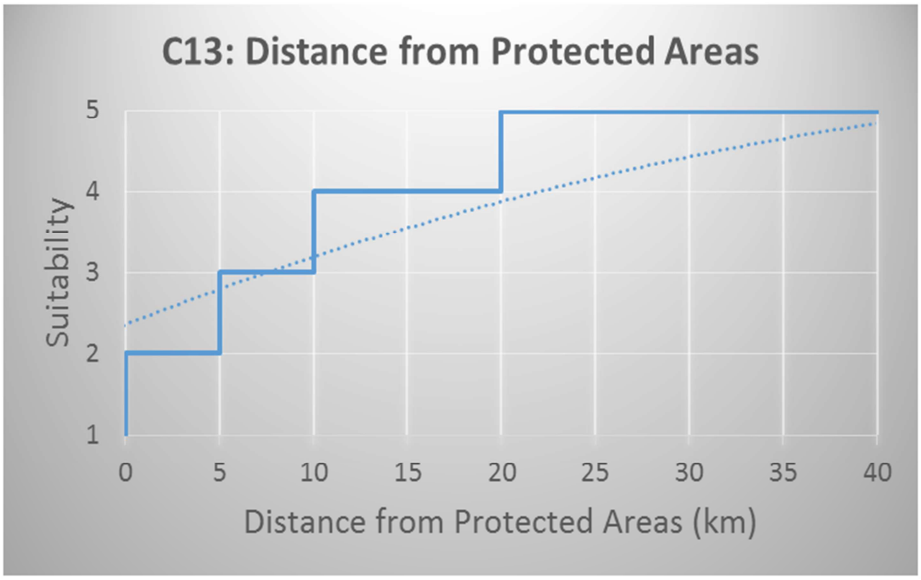

Figure 42: Suitability graph (factor 13)

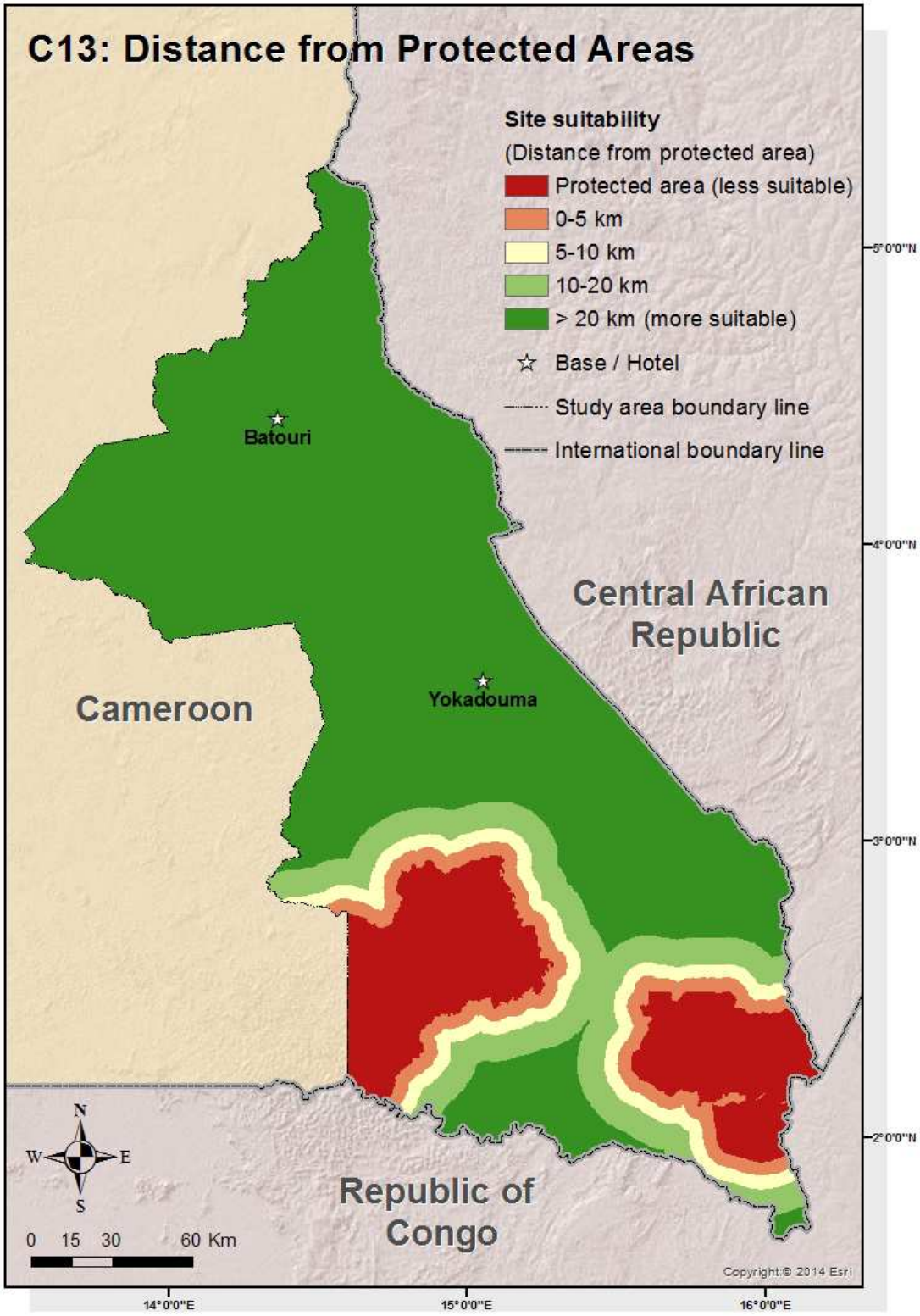

Figure 43: Distance to protected area (Euclidean distance)

3.7 Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process has been used to determine the weights of each factor. This method involves the following steps:

- **Step 1**: comparison of the criteria. Each criterion of the matrix is compared with the other criteria belonging to the same class in order to evaluate its relative importance. A scale of values between 1 and 9 is used for this purpose.
- **Step 2**: completion of a comparison matrix that will show the judgment values determined by the expert.
- **Step 3**: normalization of the values to calculate their respective weight.
- **Step 4**: calculation of the consistency ratio (CR) to appreciate how consistent is the pairwise comparison matrix.

In this research study, the factors have been divided into three classes: security related factors; human related factors and environmental factors (see Table 5).

GOAL (A)	HIERARCHY (B)	HIERARCHY (C)
Selection of the most suitable sites for mobile clinics activities	Security related factors	MSF base (C1) International border (C2) Entry point (C3) Roads (C4)
	Human related factors	Refugee population (C5) Health facility (C6) Built-up area (C7) International NGO (C8) Refugee camp (C9) Populated place (C10)
	Environmental factors	Land cover (C11) Water course (C12) Protected areas (C13)

Table 5: AHP hierarchy structure

The AHP structure adapted to this project requires the completion of four comparison matrices. The first three matrices will allow the assessment of the criteria in each of the three classes defined (Hierarchy C: first level of the AHP model). Three resulting raster layers will then be generated (one for each class) according to the weights calculated

for each factor. A last matrix will be produced to determine the weight values for the final aggregation of the three classes (Hierarchy B: second level of the AHP model).

3.7.1 Step 1: Factors Comparison

Table 6 to 8 show the score of the criteria to one another for the three classes. The text in bracket indicates the winning criterion between the two being compared.

COMPARISON MATRIX (Security related factors)		C1	C2	C3	C4
Distance to MSF base	C1	1	3 (c2)	7 (c1)	3 (c1)
Distance to international border	C2	X	1	9 (c2)	5 (c2)
Distance to entry point	C3	X	X	1	5 (c4)
Distance to road	C4	X	X	X	1

Table 6: Factors comparison (security related factors)

COMPARISON MATRIX (Human related factors)		C5	C6	C7	C8	C9	C10
Refugee population density	C5	1	7 (c5)	7 (c5)	3 (c8)	3 (c9)	7 (c5)
Distance to health facility	C6	X	1	3 (c6)	7 (c8)	7 (c9)	3 (c6)
Distance to built-up area	C7	X	X	1	9 (c8)	9 (c9)	1
Distance to international NGO	C8	X	X	X	1	1	7 (c8)
Distance to refugee camp	C9	X	X	X	X	1	7 (c9)
Populated place density	C10	X	X	X	X	X	1

Table 7: Factors comparison (human related factors)

COMPARISON MATRIX (Environmental factors)		C11	C12	C13
Landcover attraction	C11	1	3 (c11)	3 (c13)
Distance to water course	C12	X	1	7 (c13)
Distance to protected area	C13	X	X	1

Table 8: Factors comparison (environmental factors)

3.7.2 Step 2 & 3: Normalization and Weights Calculation

The first tables of each class represent the matrices completed with the comparison value (see Table 9, Table 11 and Table 13). The sum of the scores calculated in each column (thus for each factor) is added in the last row of the table.

The second tables represent the score values normalized (see Table 10, Table 12 and table 14). Each score from the first table was divided by its respective column total. For example in Table 8 (row 1, column 1): 1 / 4,48 = 0,2234, etc.

Finally, the weight is determined by extracting the average value of each row. For example, first row of Table 9: (0,2234+0,2027+0,3182+0,3261) / 4 = 0,2676.

COMPARISON MATRIX (Security related factors)		C1	C2	C3	C4
Distance to MSF base	C1	1	1/3	7	3
Distance to international border	C2	3	1	9	5
Distance to entry point	C3	1/7	1/9	1	1/5
Distance to road	C4	1/3	1/5	5	1
	SUM	**4,48**	**1,64**	**22,00**	**9,20**

Table 9: Completed matrix 1 (security related factors)

COMPARISON MATRIX (Security related factors)		C1	C2	C3	C4	Weight
Distance to MSF base	C1	0,2234	0,2027	0,3182	0,3261	**0,2676**
Distance to international border	C2	0,6702	0,6081	0,4091	0,5435	**0,5577**
Distance to entry point	C3	0,0319	0,0676	0,0455	0,0217	**0,0417**
Distance to road	C4	0,0745	0,1216	0,2273	0,1087	**0,1330**

Table 10: Normalized cell values & weights (security related factors)

COMPARISON MATRIX (Human related factors)		C5	C6	C7	C8	C9	C10
Refugee population density	C5	1	7	7	1/3	1/3	7
Distance to health facility	C6	1/7	1	3	1/7	1/7	3
Distance to built-up area	C7	1/7	1/3	1	1/9	1/9	1
Distance to international NGO	C8	3	7	9	1	1	7
Distance to refugee camp	C9	3	7	9	1	1	7
Populated place density	C10	1/7	1/3	1	1/7	1/7	1
	SUM	**7,43**	**22,67**	**30,00**	**2,73**	**2,73**	**26,00**

Table 11: Completed matrix 2 (human related factors)

COMPARISON MATRIX (Human related factors)		C5	C6	C7	C8	C9	C10	Weight
Refugee population density	C5	0,1346	0,3088	0,2333	0,1221	0,1221	0,2692	**0,1984**
Distance to health facility	C6	0,0192	0,0441	0,1000	0,0523	0,0523	0,1154	**0,0639**
Distance to built-up area	C7	0,0192	0,0147	0,0333	0,0407	0,0407	0,0385	**0,0312**
Distance to international NGO	C8	0,4038	0,3088	0,3000	0,3663	0,3663	0,2692	**0,3357**
Distance to refugee camp	C9	0,4038	0,3088	0,3000	0,3663	0,3663	0,2692	**0,3357**
Populated place density	C10	0,0192	0,0147	0,0333	0,0523	0,0523	0,0385	**0,0351**

Table 12: Normalized cell values & weights (human related factors)

COMPARISON MATRIX (Environmental factors)		C11	C12	C13
Landcover attraction	C11	1	3	1/3
Distance to water course	C12	1/3	1	1/7
Distance to protected area	C13	3	7	1
	SUM	**4,33**	**11,00**	**1,48**

Table 13: Completed matrix 3 (environmental factors)

COMPARISON MATRIX (Environmental factors)		C11	C12	C13	Weight
Landcover attraction	**C11**	0,2308	0,2727	0,2258	**0,2431**
Distance to water course	**C12**	0,0769	0,0909	0,0968	**0,0882**
Distance to protected area	**C13**	0,6923	0,6364	0,6774	**0,6687**

Table 14: Normalized cell values & weights (environmental factors)

3.7.3 Step 4: Consistency Ratio (CR)

Before applying the weights to their respective factors, it is necessary to assess whether each matrix is consistent. For this purpose, a consistency ratio is calculated according to the following formula:

CR = Consistency Index (CI) / Random Consistency Index (RI)

Where CI = (λ_{max} – n) / (n – 1)

n being the number of factors and λ_{max} the sum of the products between each weight and column totals.

The RI value comes from the method developed by Saaty (1980) and depends on the number of criteria in use.

In this work, all the CR values generated by their respective matrices have a value below 0,1 therefore they are considered consistent enough. The weights generated through these matrices can then be used during the raster layers aggregation.

Once three new raster layers (one for each class of factors) have been obtained as a result of the three different additions, it is necessary to evaluate the influence of each class to one another.

This requires a second AHP process in order to assign weights for each of the three resulting rasters (one weight per class). Table 15 and 16 show the comparison process between classes (Cl).

COMPARISON MATRIX		Cl 1	Cl 2	Cl 3
Security class	**Cl 1**	1	1	5
Human class	**Cl 2**	1	1	7
Environmental class	**Cl 3**	1/5	1/7	1
	SUM	**2,20**	**2,14**	**13,00**

Table 15: Completed comparison matrix

COMPARISON MATRIX		Cl 1	Cl 2	Cl 3	Weight
Security class	**Cl 1**	0,4545	0,4667	0,3846	**0,4353**
Human class	**Cl 2**	0,4545	0,4667	0,5385	**0,4866**
Environmental class	**Cl 3**	0,0909	0,0667	0,0769	**0,0782**

Table 16: Normalized cell values & weights

3.8 Aggregation of the Results

Boolean overlay is the simplest method to aggregate several criteria, particularly if there are areas that can be eliminated in the early stage of the analysis. However it does not offer a lot of flexibility since it is based on binary operations with only two possible outcomes: true or false (all the factors end up having the same influence).

For this reason, a weighted overlay approach has been used in this project as it is much more adequate in a human related context where reality cannot be divided in only two categories with very sharp edges. Many factors will influence the site suitability but they don't have the same importance in regards with the objective. Therefore a weighted linear combination has been used to aggregate the different raster layers obtained after each AHP step.

The weighted sum can be represented by the following formula:

$$S = \sum w_i f_i \times \prod c_j$$

Where S is the suitability, w the weight of the factor i and f the criterion score of the same factor i. The letter c represents the score of the constraint j if some Boolean constraints need to be applied to the analysis.

A multiplication is performed between each raster layer and its respective weight by using the weights allocated during the AHP. The results of each multiplication are summed up together in order to generate a suitability map.

Two Analytic Hierarchy Processes induce two weighted overlay (one for each level, see Table 5). The first weighted overlay resulted in three suitability maps (one per class). The second weighted overlay resulted in the final suitability map.
The operation has been performed using a tool in ArcGIS ("Weighted Sum") allowing us to combine the addition between the raster layers of the same class according to their respective weights.
The final suitability map obtained at the end of the process gives an overview of the most strategic areas to run mobile clinic activities.

4. RESULTS

4.1 Analysis 1 (with Security Considerations)

4.1.1 Suitability Maps

By following the methodology described in the previous chapter, three suitability maps have been produced. They feature the most strategic areas according to the influence of the 13 factors in each of their respective class (see Figures 44 to 46).

The areas showing a higher suitability appear in darker green on the maps.

These three maps will be overlaid together (second weighted overlay) based on the weights calculation from the second Analytic Hierarchy Process. The most suitable areas they share will be highlighted according to their respective influence.

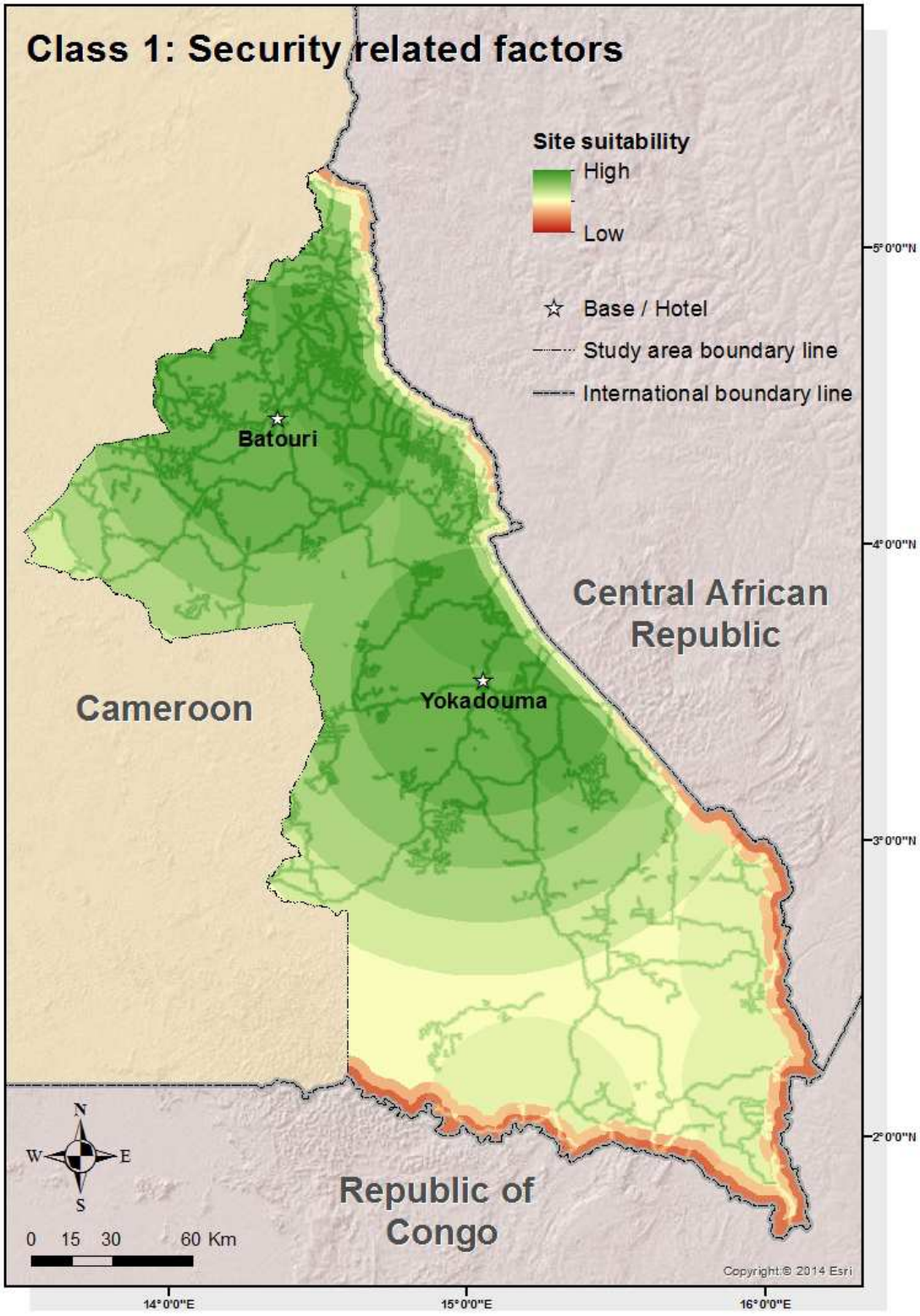

Figure 44: Site suitability (security related factors)

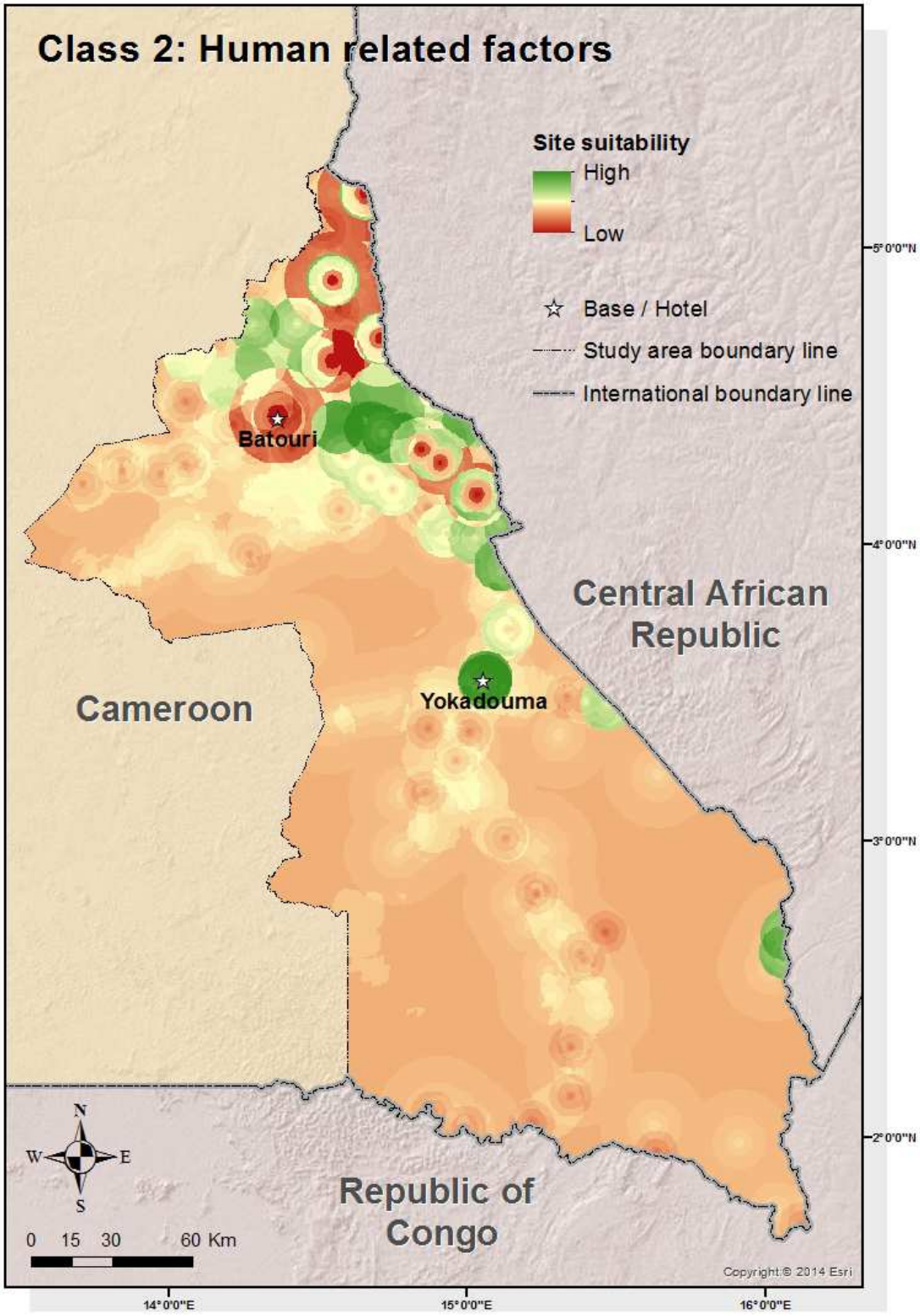

Figure 45: Site suitability (human related factors)

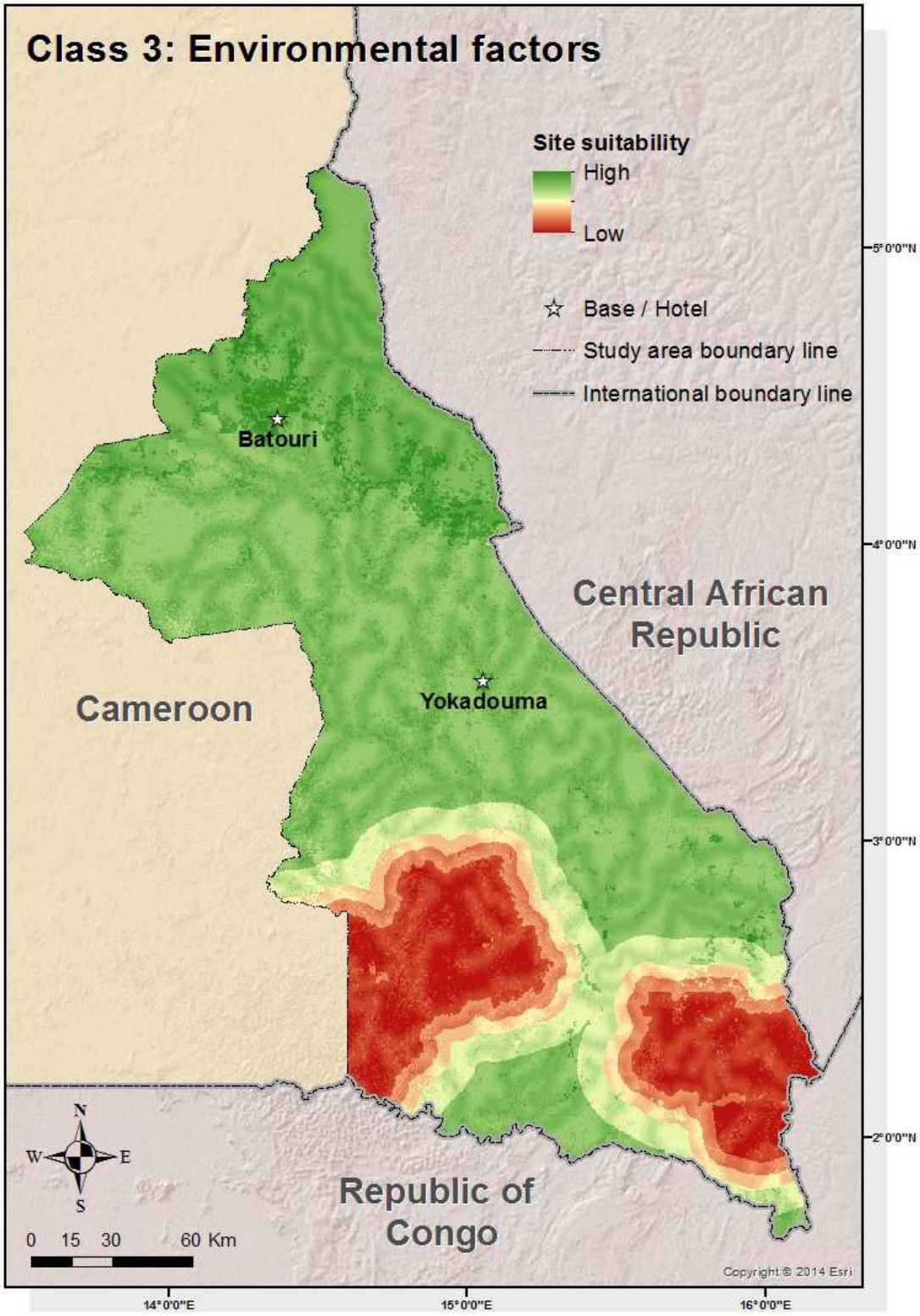

Figure 46: Site suitability (environmental factors)

Figure 47 shows the outcome of the second AHP process (see weights in Table 16).

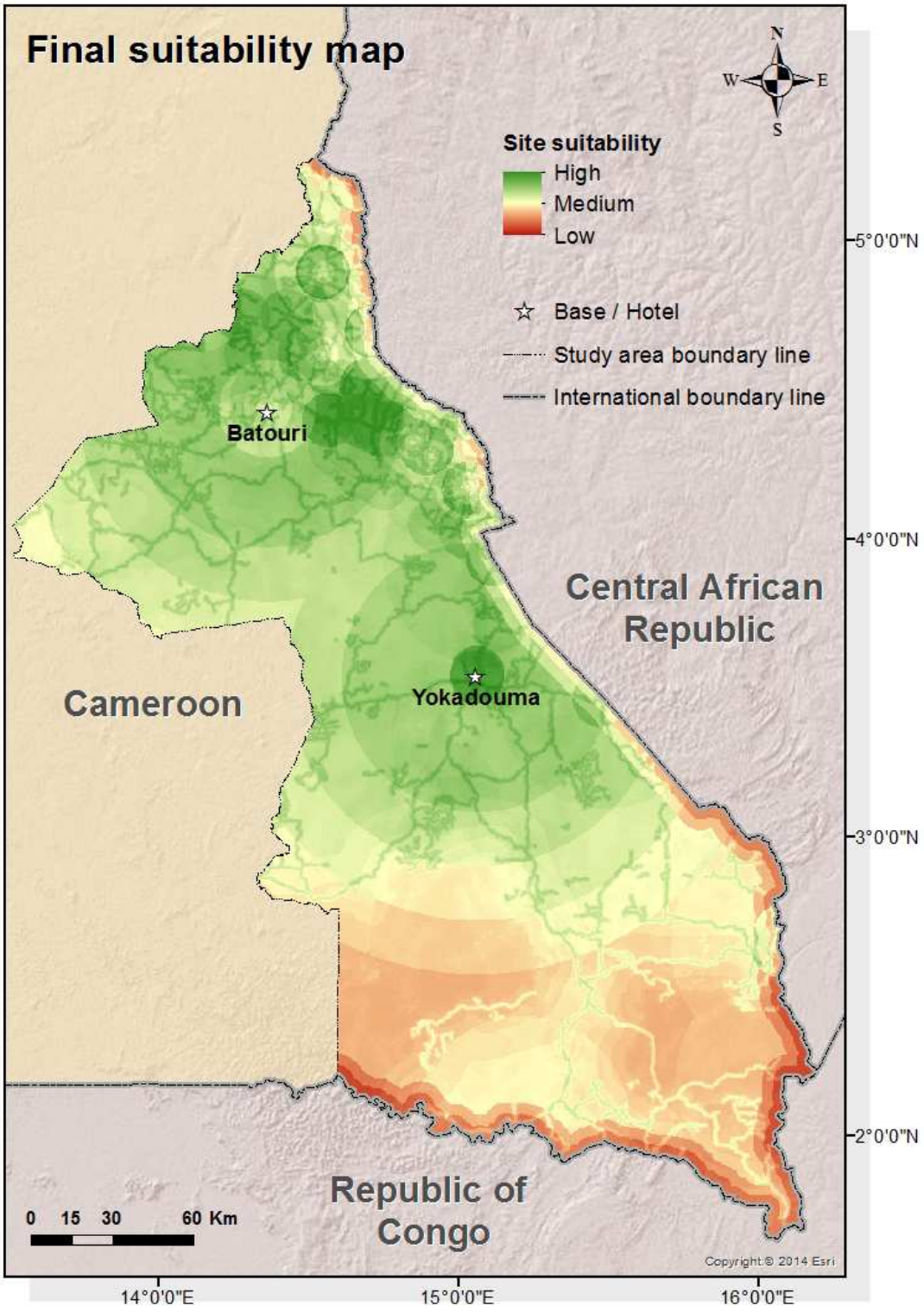

Figure 47: Final suitability map (Analysis 1)

This map illustrates where the most suitable areas are situated according to the 13 factors taken into consideration. Three zones show a very high suitability: an area surrounding and including Yokadouma, and two areas near Batouri, in the North and particularly in the East of the town. The mobile clinics should focus on these areas to increase the chances to reach the refugee populations.
On the other hand, the southern part of the study area seems clearly inappropriate to implement health activities. This is mostly related to the distance from the MSF bases, the presence of national parks and forest reserves as well as the land cover type (closed forest area).

4.1.2 Most Suitable Areas and Towns

To keep a mobile clinic team fully active, a number of eight sites should be selected (four sites per week, visited every two weeks). However, no algorithm can anticipate the reality and possible challenges of the field. Therefore the analysis should not be too restrictive and a higher number of alternatives should be suggested with a priority order.

Considerations

There are certain facts to keep in mind when planning outreach activities as not all influential factors can be spatially localized.
For example, MSF teams cannot show up in villages and start the activities without prior visits and discussions with the community leaders and “chefs coutumiers” (village chiefs).
These key stakeholders confirm and update the organization about the refugee movements and known localizations. They will also give their authorization to have the NGO work in their village. It is rare but possible that due to a sensitive history with NGOs (or for any other reasons) a community may not be interested to be a focal point for mobile clinics.

On the other hand, if the MSF activities are welcome and desirable by the population, some support may be requested from the community to increase the effectiveness of the mobile clinics. Their leaders should be passing the information about the MSF arrivals

among the refugees; they should identify daily workers in advance (crowd controllers, sensitizer...) and identify/prepare a place large enough where MSF can properly run the activities.

The main goal is to treat as many patients as possible. If the villagers or refugees do not show any interest or motivation to facilitate the MSF aid, the mobile clinic may be relocated to a more active town.
For all these reasons, it is important to be flexible with the final site selection. The most reasonable approach would be to list a limited number of suitable places from which the decision makers can pick according to the context and the reality of the field.

In addition to obvious criteria (the 13 factors used in the analysis), other aspects are considered as decisive:

- Selecting sites distant from each other, in strategic or centralized locations (e.g. positioned at roads intersections). As a result:
  - Wider areas can be covered if the activities are spread out in a logical manner (thus more patients potentially treated).
  - Risk of overlap is reduced (if MSF works in two neighbouring towns, beneficiaries may decide to visit the clinics twice to try and get more drugs or therapeutic food).
  - Covering distant places help to do some kind of surveillance of the situation.
- Prioritizing towns with a significant size and a weekly market.
- Prioritizing towns where the access to clean water and sanitation is difficult (with a higher risk of disease).
- Prioritizing places where the local health centre may not be very operational, is overwhelmed, runs out of human and material resources or requires training.

GIS has helped to perform a first screening of the study area to identify the most suitable areas. However the first action plan proposed will only serve as a start plan. It will require further adaptation according to the first feedbacks from the field.

Results

In order to simplify the interpretation and to offer clear indications to the final users, it was necessary to extract the most suitable areas from the maps. However, there are no standard rules to categorize continuous data in such a project. The division of the resulting data is left to the field experts own judgments. Each expert has his/her own appreciation of the context and of the factors.

To ensure that the results will be practical and fit to the reality of the field, it was decided to use existing towns and places whose geographical coordinates were recorded directly by the MSF team during the first field assessments.

To offer a better perspective in the decision making process, the final suitability map (see Figure 47) is reclassified and divided into 20 ranges of values (of equal interval) according to each raster cell value (1 cell = 100 x 100 m^2). This step allows highlighting the most suitable areas (top ranges of values), identifying their most strategic towns and selecting the ones that could potentially hold the MSF activities.

But to what extent can we say that an area is suitable or not? How many km^2 should cover suitable areas to offer a well-defined target without being too restrictive?

After considering different scenarios to strike a good balance when selecting the highest ranges of values, it has been determined that ensuring a minimum of 8 working sites would initially necessitate:

- A total ”most suitable area” below 2000 km^2 (to keep focus on the best areas)
- A number of potential sites of at least 16 towns ranked by priority group (to facilitate the decision making)

At this stage, the field constraint areas (where refugees would not realistically settle) must also be eliminated. Two types of constraints have been considered in the analysis:

- National parks (the most restrictive of the protected areas)
- Permanently flooded areas

The restricted areas (constraint) appear in dark grey (Figure 48).

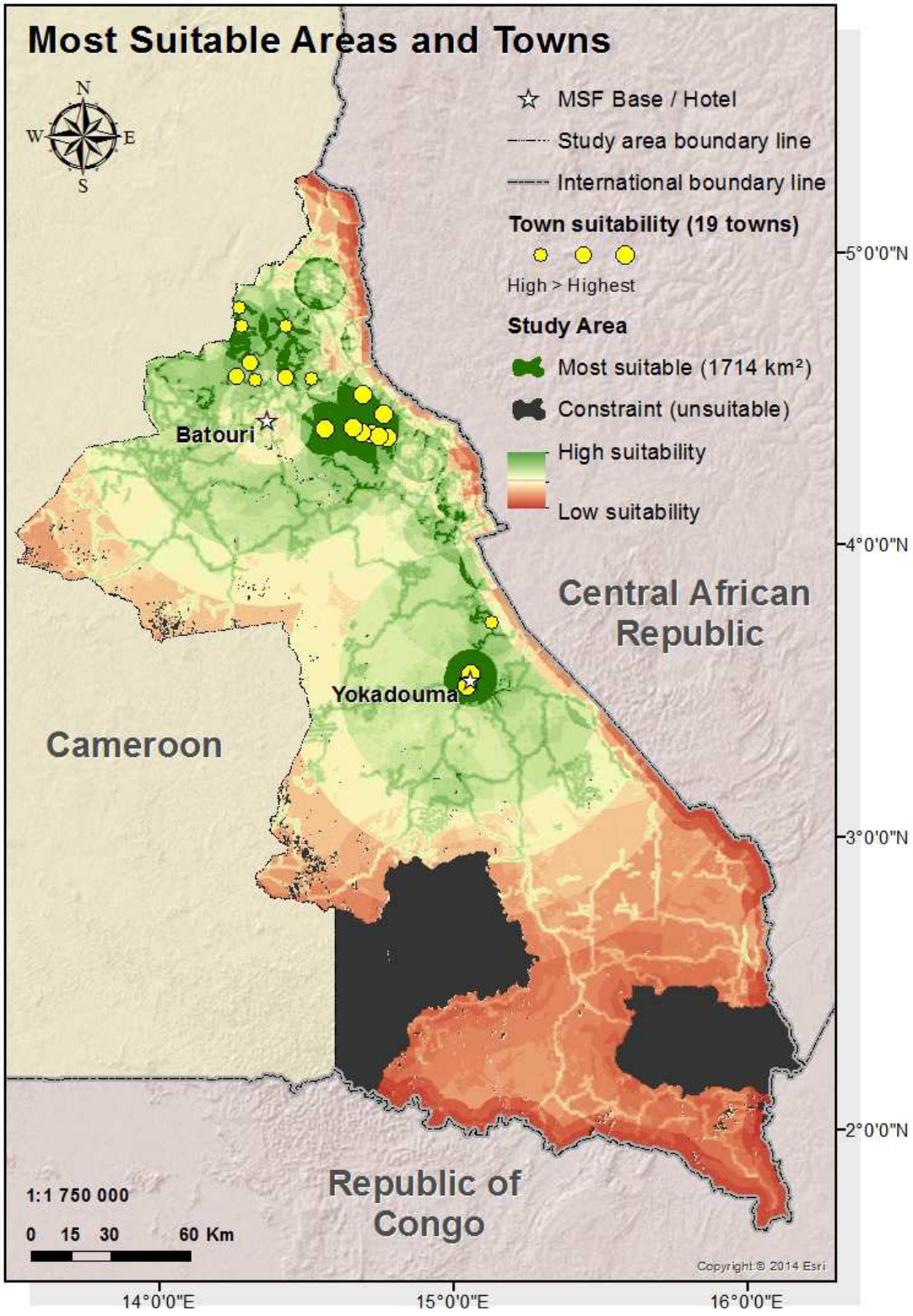

Figure 48: Most suitable areas (1714 km²)

Based on the reclassification and known constraints, the three most suitable ranges are selected as well as their respective number of towns (Table 17).

Suitability value	Area covered (km^2)	% of the total study area	Number of noticeable towns within
20 (Highest suitability)	268	0,57	10
19	625	1,34	3
18	821	1,75	6
Total	**1 714**	**3,66**	**19**

Table 17: Suitable areas and number of potential sites

As can be seen in Table 17, the most suitable area (highest range of values) cover 268 km^2 and includes 10 towns. The yellow dots displayed on the map (see Figure 48) represent the noticeable towns located in the three most suitable areas (dark green). Larger is the dot and more suitable is the area in which they are situated.

Suitability value	Number of noticeable towns within	Noticeable towns names
20 (Highest suitability)	10	*Belita, Belimbam, Boma, Gaina, Ndong Doube, Koele, Nyabi, Ngarissingo, Yokadouma, Vale*
19	3	*Garua Sambe, Pandi, Yoko*
18	6	*Dja, Lala, Mang, Ngbakine, Mboumama, Taparé*
Total	**19**	

Table 18: Relevant towns per suitability class

Table 18 shows the noticeable towns of the three highest ranges of values (considered as “most suitable area”). Experts and field workers can then make their decision by strategically selecting the sites/towns according to the suitability areas they belong to. The final decision relies on a good experience and knowledge of the field.

4.2 Analysis 2 (with no Security Considerations)

4.2.1 Factors Classification and Weighting

Among the different criteria taken into consideration to conduct the first analysis (with security considerations), some of them were correlated to the security management based on the East Cameroon context (see Section 2.3).
If security was not an aspect to take into consideration, most of the security class criteria would have no influence on the site suitability.

Therefore in this second analysis, the three following factors have been removed from the analytical hierarchy process structure:

- Distance to MSF base → No security risk means that chances to have a car accident with a logging truck or to run into a roadblock at night are very low. In this hypothesis, there is no obligation to drive only during daylight or to be back in the base every night. The MSF team could be deployed anywhere in the study area and spend the night in any village. This factor becomes irrelevant.

- Distance to International border → No security risk means that no rebel groups are going to cross the border for robberies or attacks. In this hypothesis, MSF teams could be deployed anywhere close to the border without any buffer distance. This factor also becomes irrelevant.

- Distance to Roads → No security risk means that the staff does not need to stay and work within sight of the MSF cars. They could potentially hike or move to any point in the study area. Therefore, there is no need to stay along the roads. This factor becomes irrelevant.

However, the fourth factor of the security class (distance to entry point) needs to be kept and adapted. Indeed, the number of refugees will likely be higher near these entry points than in other places along the border. Table 19 shows the reclassification of the criteria if the security did not need to be taken into consideration.

CLASS	FACTOR	#	RECLASSIFICATION				
			1	2	3	4	5
Security related	~~*Distance from MSF base (km)*~~	~~*C1*~~	~~*>110*~~	~~*90-110*~~	~~*70-90*~~	~~*50-70*~~	~~*0-50*~~
	~~*Distance from International border (km)*~~	~~*C2*~~	~~*0-0,5*~~	~~*0,5-1*~~	~~*1-4*~~	~~*4-8*~~	~~*>8*~~
	Distance from Entry points (km)	C3	>30	20-30	10-20	5-10	0-5
	~~*Distance from Roads (m)*~~	~~*C4*~~	~~*>1000*~~	~~*600-1000*~~	~~*400-600*~~	~~*200-400*~~	~~*0-200*~~
Human related	Refugee locations density	C5	Low =======> Medium =======> High				
	Distance from MoH health facilities (km)	C6	0-1	1-2	2-5	5-8	>8
	Distance from Built-up areas (km)	C7	>20	10-20	5-10	2-5	0-2
	Distance from International NGOs (km)	C8	0-2	2-4	4-9	9-18	>18
	Distance from Refugee camps (km)	C9	0-1	1-3	3-6	6-12	>12
	Populated places density	C10	Low =======> Medium =======> High				
Environmental	Land cover attraction	C11	Low =======> Medium =======> High				
	Distance from Water courses (km)	C12	>4	3-4	2-3	1-2	0-1
	Distance from Protected areas (km)	C13	<0	0-5	5-10	10-20	>20

Table 19: Factors reclassification (if the security constraints are not considered in the analysis)

As explained above, three factors previously related to the security class have been removed from the analysis (see strikethrough cells in Table 19).
The "distance to entry point" factor has been updated and transferred to the human related factors class (as it is not related to security anymore but to human activities).

The change in the reclassification to perform a second analysis requires new analytical hierarchy processes. Comparison matrices should be updated according to the new criterion of the human related factors (refugee entry point). This will alter the weight of each factor. Instead of three classes, only two will be considered in the analysis.

The environmental class structure remains the same as in the first analysis. The human related class is updated and includes the new factor (C3 Refugee entry points). Table 20 and 21 show the comparison matrix modified accordingly.

COMPARISON MATRIX (Human related factors)		C3	C5	C6	C7	C8	C9	C10
Distance to entry point	**C3**	1	1/3	5	7	1/5	1/5	7
Refugee population density	**C5**	3	1	7	7	1/3	1/3	7
Distance to health facility	**C6**	1/5	1/7	1	3	1/7	1/7	3
Distance to built-up area	**C7**	1/7	1/7	1/3	1	1/9	1/9	1
Distance to international NGO	**C8**	5	3	7	9	1	1	7
Distance to refugee camp	**C9**	5	3	7	9	1	1	7
Populated place density	**C10**	1/7	1/7	1/3	1	1/7	1/7	1
	SUM	**14,49**	**7,76**	**27,67**	**37,00**	**2,93**	**2,93**	**33,00**

Table 20: Factors comparison (human related factors)

In Table 21 new weights were calculated for each factor of this class according to the same AHP methodology previously used.

COMPARISON MATRIX (Human related factors)		C3	C5	C6	C7	C8	C9	C10	Weight
Distance to entry point	**C3**	0,0690	0,0429	0,1807	0,1892	0,0683	0,0683	0,2121	**0,1186**
Refugee population density	**C5**	0,2071	0,1288	0,2530	0,1892	0,1138	0,1138	0,2121	**0,1740**
Distance to health facility	**C6**	0,0138	0,0184	0,0361	0,0811	0,0488	0,0488	0,0909	**0,0483**
Distance to built-up area	**C7**	0,0099	0,0184	0,0120	0,0270	0,0379	0,0379	0,0303	**0,0248**
Distance to international NGO	**C8**	0,3452	0,3865	0,2530	0,2432	0,3413	0,3413	0,2121	**0,3032**
Distance to refugee camp	**C9**	0,3452	0,3865	0,2530	0,2432	0,3413	0,3413	0,2121	**0,3032**
Populated place density	**C10**	0,0099	0,0184	0,0120	0,0270	0,0488	0,0488	0,0303	**0,0279**

Table 21: Normalized cell values & weights (human related factors)

The consistency ratio CR (see Section 3.7.3) was calculated and equals 0,080367. Since the value is below 0,1 the matrix is considered consistent enough.

The aggregation of the two raster layers (human related factors + environmental factors) will be performed after a new comparison matrix determined the weights of each class. It will be a more basic process as it only handles two classes (see Table 22).

In order to remain consistent with the first analysis (see Section 3.7.3), the same judgment value is assigned to the Human related class when being compared with the Environmental class. The Human related factors are considered 7 times more important (see Table 22). Table 23 reflects the modification of the final AHP comparison matrix.

COMPARISON MATRIX		**Cl 2**	**Cl 3**
Human class	**Cl 2**	1	7
Environmental class	**Cl 3**	1/7	1
	SUM	**1,14**	**8,00**

Table 22: Completed comparison matrix

COMPARISON MATRIX		**Cl 2**	**Cl 3**	**Weight**
Human class	**Cl 2**	0,8750	0,8750	**0,8750**
Environmental class	**Cl 3**	0,1250	0,1250	**0,1250**

Table 23: Normalized cell values & weights

4.2.2 Suitability Map

Finally, a map can be generated by using the Weighted Sum algorithm with the new calculated weights (see Figure 49). This map highlights the most suitable places where mobile clinic activities could be implemented if there was no security issue in the region.

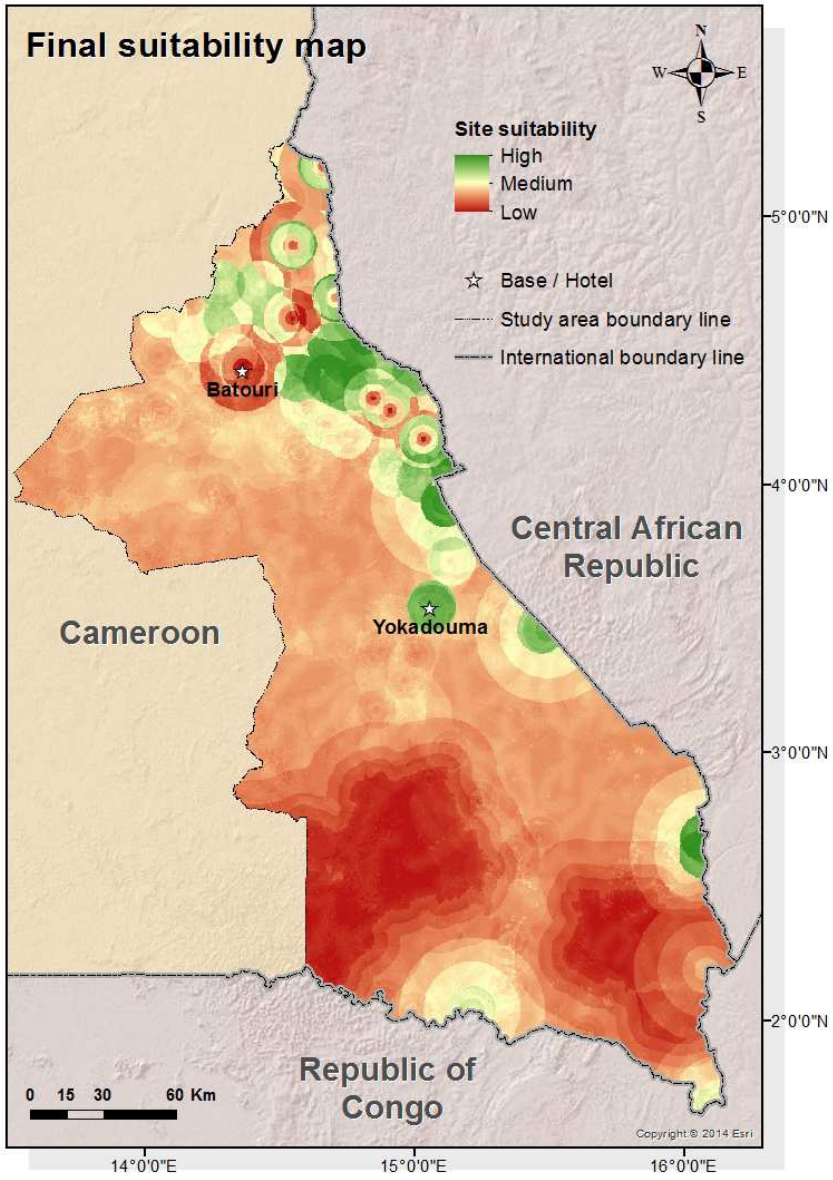

Figure 49: Final suitability map (Analysis 2)

As can be seen on the resulting map, the absence of security risk has a significant impact on the suitable areas suggested by the analysis. This second map strongly suggests focusing on areas situated near and along the international border. The results are reasonable given the modification of the number of factors and their new weights.

4.2.3 Most Suitable Areas and Towns

By using the same method as in the previous section (see 4.1.2), noticeable towns located within the most suitable areas are counted and identified (see Table 24 and 25). Working in or near a town with people eager to facilitate the activities remains the most effective method to pass the information and gather refugee population living in the vicinity.

In the first analysis, the three most suitable areas were used. Due to a lower area extent (thus a limited number of towns) in the second analysis, it has been decided to include the fifth most suitable ranges of values to cover a minimal area and to ensure that decision makers would have enough alternatives during their final discussions (see Figure 50).

Suitability value	Area covered (km^2)	% of the total study area	Number of noticeable towns within
20 (Highest suitability)	33	0,07	0
19	225	0,48	5
18	437	0,93	3
17	586	1,25	4
16	612	1,31	6
Total	**1 893**	**4,04**	**18**

Table 24: Suitable areas and number of potential sites

Suitability value	Number of noticeable towns within	Noticeable towns names
20 (Highest suitability)	0	/
19	5	*Gaina, Libongo, Ndong Doube, Weissambo, Bella*
18	3	*Mbombete, Vale, Gari Gombo*
17	4	*Belita 2, Boma, Nyabi, Ngarissingo*
16	6	*Belimbam, Château, Djalingou, Mboy 1, Koele, Yokadouma*
Total	**18**	

Table 25: Relevant towns per suitability class

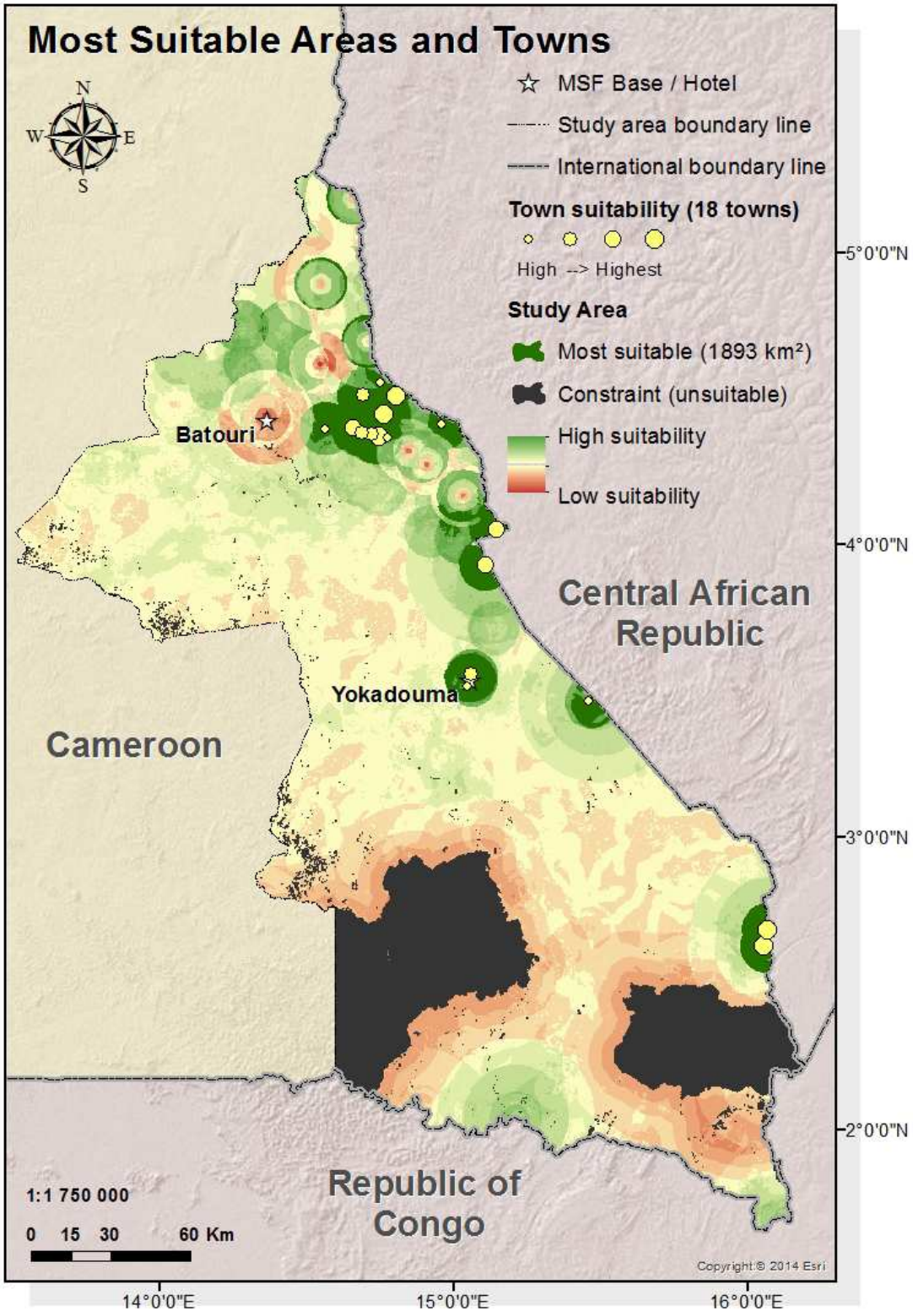

Figure 50: Most suitable areas (1893 km²)

5. DISCUSSION

5.1 Objective 1: GIS and Outreach Health Activities

To give a better perspective and appreciation of the study objectives, the results were compared with data from the actual 2014 MSF emergency in Cameroon.

The first comparison (see Figure 51) illustrates the outcome of the first analysis (see Section 3.7 and Section 4.1) with the MSF mobile clinics that were carried out in the field in 2014 (without the use of the GIS tool).

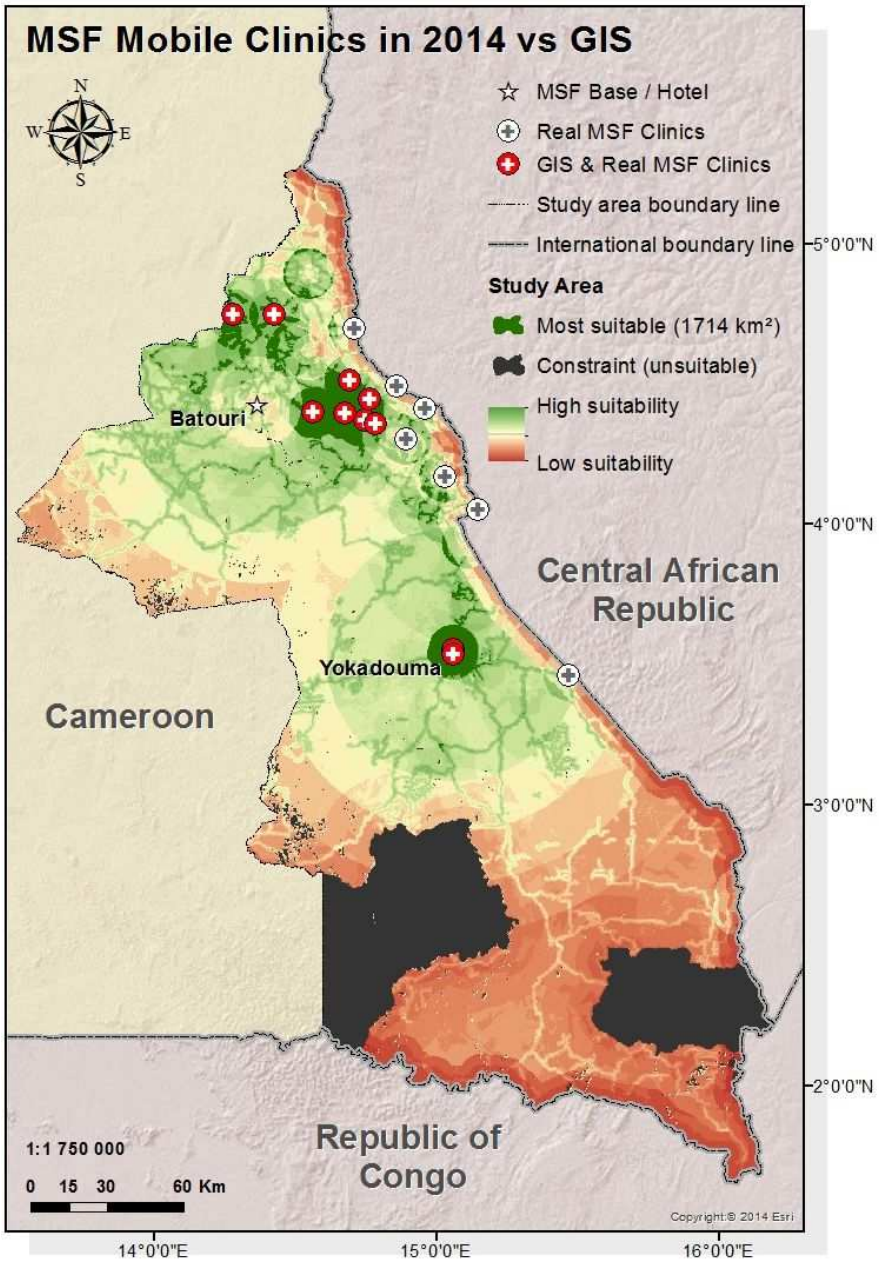

Figure 51: Real MSF clinics vs GIS analysis

The map displays where the MSF mobile clinics took place during the 2014 emergency (cross symbols). That includes all the sites visited once or more.

It also shows that the GIS analysis allowed the identification of 10 out of 16 sites that were also selected during the 2014 emergency. Some of the MSF sites used in 2014 proved to be very strategic, receiving a significant number of beneficiaries while other sites were a bit less successful.

In order to highlight these "most pertinent" working sites, they were compiled and listed (see Table 26). The table shows the sites visited with regularity during the last 2 months of the mobile clinics program with the respective number of visits. The decision to work in these locations was discussed in weekly team meetings involving all the MSF coordinators and supervisors related to the outreach activities (i.e. field coordinator, outreach focal point, medical team leaders and logistics team leaders).

MSF Emergency Mission Data		**GIS analysis (with security considerations)**
Visited Site	**Number of visits (last 2 months of the mission: Sept-Oct 2014)**	**Identified by GIS?**
Ndong Doube	8	yes
Ngarissingo	8	yes
Boma	5	yes
Koele	5	yes
Gari Gombo	4	no
Mbombete	4	no
Nyabi	4	yes
Belimbam	3	yes
Gaina	3	yes
Mboumama	3	yes
Sanji 2	3	no
Taparé	3	yes
Château	2	no
Kentzou	2	no
Mboy	2	no

Table 26: Sites visited during the 2014 emergency mission (MSF, 2014) vs GIS Analysis

When comparing the results of the GIS analysis with the MSF Outreach schedule (Table 26), we can observe that:

- ✓ The GIS analysis identified 9 sites in common with the 2014 MSF mission. These common sites turned out to be among the 12 most visited locations by MSF in 2014 which indicates that they were seen as the most pertinent working sites by the team.
- ✓ The GIS analysis clearly identified the 4 most visited sites. They are located in the highest site suitability range of the GIS analysis (see Table 18).
- ✓ The sites that are not identified by the GIS are also the ones with fewer visits (less "success"). MSF ended the activities there earlier: Kentzou, Château and Mboy.
- ✓ Two sites were not identified by the GIS even though they were actually visited regularly (Gari Gombo and Mbombete). They are both situated very close to the international border with CAR but the presence of Cameroonian authorities in this area increased security. MSF took advantage of this particular situation to maintain the mobile clinic project in these places a bit longer than otherwise expected.

Based on this comparison, the analysis turned out to have identified sites that were actually some of the most pertinent places where the MSF teams worked in 2014 (i.e. Ndong Doube Ngarissingo, Koele, Boma, Nyabi, Belimbam, Gaina, Taparé and Mboumama). Furthermore, it ruled out sites where the MSF presence happened to be a bit less effective or strategic (i.e. Kentzou, Château and Mboy).

GIS can be an added value to support the decision making process provided that up-to-date dataset are available and can be directly included in the analysis. It is however limited to some degree if the reality in the field happens to involve very localized influence (e.g. presence of authorities, high number of refugees coming to the clinics due to a more effective health promotion from the local community, etc.).

5.2 Objective 2: Impact of Security on Site Selection

The second and main objective of the study aims to show whether the security context has a significant impact on a final action plan. In other words, would MSF decision makers focus the effort of the mobile clinic teams in different locations if security related factors were taken into consideration during their strategy discussions?

The comparison between Figure 48 (analysis with security related factors) and Figure 50 (analysis without security related factors) illustrates the security impact towards the MSF activities.

In order to select the most suitable areas below 2000 km² while including at least twice more noticeable towns than the eight required for the mobile clinic, it has been necessary to pick:

- The three higher ranges of values (or higher suitability ranges) in the analysis 1. It represents an area of 1714 km² and contains 19 relevant towns.
- The five higher ranges of values (or higher suitability ranges) in the analysis 2. It represents an area of 1893 km² and contains 18 relevant towns.

Both maps have only 10 selected towns in common. This comparison confirms that the security has a significant impact. It influences almost up to 50 percent of the result: 9 out of the 19 sites selected by analysis 1 (with security considerations) were not selected when performing analysis 2 (with no security considerations).
These are mostly the sites located along the border, especially near the refugee entry points.

It is important to bear in mind that this comparison is strongly related to the humanitarian situation of this particular context. Security will likely have higher or lower influences in other circumstances and countries.

6. CONCLUSION

6.1 GIS and Humanitarian Health Activities

Through this practical example, the study demonstrated that GIS offers an added value in the selection of the most suitable sites for humanitarian outreach health activities such as mobile clinics. It helps clarify where the teams should focus their initial efforts which allows for a significant savings of time and energy. In this particular context, saving time means treating more people. It also implies more funds saved to either lengthen the activities or open new initiatives in other places.

Objectives

As discussed in the previous section, pertinent sites were highlighted with the GIS analysis compared to the MSF emergency response that actually took place in 2014: 9 of the 12 most visited sites in reality were also selected with the GIS analysis. In addition, it ruled out the sites that were less relevant, thus less visited during the 2014 emergency.

The study also showed that the security aspect in such a humanitarian context will have a significant impact in the action plan if the security related factors are taken into consideration. Security appears to influence up to 50 percent of the results (the two analyses only share 10 sites in common).

On top of the study objectives, GIS revealed other advantages:

- It centralizes the information in the form of geographical data, which can be very useful for the different departments and stakeholders for their daily work.
- It is a practical visualization and decision support tool to back-up a first action plan.
- It provides a clear and visual track of the MSF working locations and/or future plans. This is a very useful asset in MSF missions where the work conditions and contexts logically implicate a high turn-over of the international workers' supervisors. GIS helps mitigate the loss of information during the transitions.

Methodology

In terms of methodology, this project showed that using MCDA to include and compare knowledge from different sources is effective and provides pertinent results. Selecting the appropriate MCD method is an important step in the process. While none of all the known method outclasses the others in all circumstances, the idea was to use the most appropriate one according to the type of analysis undertaken, the objectives, the available information and the background of the stakeholders involved. In our case, the real added value of MCDA, and particularly of the AHP methodology, was the possibility of including the knowledge directly into the weighting process. This approach proved to be very practical for our suitability analysis. The AHP multi-class structure is straightforward to comprehend for both experts and non-experts. Any change occurring in the field could easily be adapted into the weighting process as soon as data is collected. This flexibility is a crucial asset in volatile humanitarian contexts.

In addition, and considering the high number of criteria involved, the AHP classification process turned out to be the most reasonable. It organizes the research question into several levels, which allows for a better understanding of the whole situation for decision makers. Comparing the factor in pairs and per class is indeed much more judicious in this project than for instance trying to rank all these factors together in a one-step operation (e.g. ranking method). As an expert, it is not an easy task to directly assign weight to many factors and the pairwise comparison is a simple and effective tool for this purpose. It also imposed to carefully consider each criterion during the analysis and significantly helped to appreciate how much each class or factor really influences the final result. At last, the consistency ratio results ensured an accurate weighting of the different factors involved and validated the pairwise comparisons process. With the help of two parallel AHP analyses, this research clearly showed that the security constraints related to this humanitarian context has an impact on the results and would significantly affect the final action plan.

Compared to other dangerous environments where the MSF organization tends to work, the South-Eastern Cameroonian context is relatively safe. Despite the neighbouring civil war, most of the initiatives can usually be implemented. Knowing this, it is easy to understand that the security situation in more challenging contexts has an even higher impact on the NGO activities, often preventing any type of mobile strategy or deployment in the field.

6.2 Limits and Suggestions

In spite of a positive usage of the GIS in this study, it is important to take into account the limits of its application. No matter how powerful the technology, it will never overcome erratic data. It is easy to forget this point, especially for field workers who may base their decision according to the sole resulting map. For this reason, communication is essential between the analyst and the decision makers.

Data Reliability

The results of the research are only as reliable as the dataset that has been used during the analysis. Most of the data incorporated in the process has been collected from the field but it is hard to collect complete and consistent data. It is sometimes not yet accessible or it is simply based on rumours or unreliable sources. Datasets from the internet such as the built-up areas or the road network from the OpenStreetMap project sometimes show some discrepancies in the study area where it has not yet been fully digitalized (e.g. unfinished secondary or tertiary roads). During a humanitarian emergency, this is usually fixed with special requests made by MSF to the very active OSM volunteers' community. In a matter of hours or days, they are able to finalize the digitalization of satellite data into geographical dataset that can be directly used by the GIS officer working in the field.

Data concerning structures are usually very reliable (e.g. refugee camps, health centres and health organizations) and comes from trustworthy sources (i.e. United Nations, local authorities and NGOs). On the other hand, data involving refugees' locations are as important to gather as they are more difficult to locate. They have a high influence in the MSF strategy but they can be subject to changes and movements due to this unstable humanitarian context. It requires a constant information follow-up from the mobile clinic coordinators. Data must be constantly checked and rechecked when meeting different sources who sometimes have different objectives (i.e. refugee representative vs. village chiefs, etc.). The information can eventually be cross-checked and offer some reliability but in certain cases and areas, it is highly labour and time intensive for the MSF team.

The refugee location density is directly based on MSF field work but due to a lack of time it was not possible to assess every single "grey" zone[2] of the study area. A new refugee pocket of a few hundred people could easily affect the results once it is added to the existing dataset. Since this study was conducted after the field mission, it has not been possible to verify the reliability of all the layers with ground truth information, especially with data coming from internet sources (e.g. land cover or water courses). A check against the "real world" is probably necessary to improve the consistency of the analysis.

No matter how much data can be collected, the reality of this context will always change faster than the information can spread. It should not bring the analysis to an end but a high flexibility must be kept during the whole process so that updates can be made on a short notice to adapt the decisions to the field requirements.

Humanitarian Emergencies and Volatility

As in most humanitarian contexts, the characteristic of this environment is the high level of instability due to the neighbouring civil war. Any mid-term to long-term projections are extremely difficult to make. Data that is accurate in the first week can be completely out of date two weeks later. Under these circumstances, one must be constantly aware of the changes and ready to update datasets and analyses as soon as possible. The GIS use for outreach activities may be less decisive in very volatile contexts involving daily changes compared to a more stable situation requiring mid-term deployment plans based on steady data and environment (e.g. malnutrition mobile activities according to reliable monthly statistics). Despite a meticulous analysis, it is hard to predict how successful a mobile clinic will be before actually experimenting it on site. No one can truly forecast how many refugees will come and if they have been informed properly.

[2] A "grey" zone is an area that has not been fully assessed by the MSF team.

Other Influences

Experts and decision makers should also be aware of what is missing in the analysis. What information out there in the real world could also influence mobile health clinic movements? What additional factor would be worth adding? For example, knowing that the study area has significant gold and diamond resources, it could be relevant to avoid working near illegal mining activities where insecurity may increase, provided that such locations are known. Depending on the time of the year, it is also pertinent to identify the roads becoming inaccessible during the rainy season. Identifying water accessibility in different areas may also help in defining priorities to respond to emergencies. Focus can be given to overpopulated places with a limited number of access points available.

Subjectivity of the method

The methodology and weighting process used in the analysis have a substantial effect on the results as well. Since reclassification is typically based on a judgment of values from experts, it has a limited objectivity. The analytical hierarchy process (AHP) requires the comparison of each factor from the same class to one another. Different comparison scores between factors logically induce different outcomes.

Field experts' experiences and common sense usually dictate their decisions but the conversion from verbal appreciations to numerical scales would always remain subjective. This subjectivity may cause significant divergences in the appreciations, especially in the humanitarian world where decision makers come from distinctive backgrounds and have experienced all types of missions. Converting the security context of a whole region into numbers is a very complex task. In reality, based on similar rules, two theoretically comparable sites (with the same suitability value) can happen to be quite distinctive regarding their local security context. Being in Cameroon during this humanitarian crisis, my knowledge of this context was very beneficial to appreciate the reliability of this study.

Suggestions

Considering that a GIS analysis should be quick and realistic measure to offer immediate and usable solutions for the field staff, I would suggest utilizing simple methods according to the number of criteria available. Ranking or rating methods may

be sufficient if the number of factors is limited. The AHP is very suitable for a larger number of factors or to anticipate the accumulation of new criteria. While the AHP methodology proved to be effective in this study, it would also be interesting to combine it with fuzzy logic in order to handle imprecise situations and bring more objectivity to the analysis.

Finally, aiming for very restrictive results should be avoided. Having a highly limited number of alternatives might be counterproductive. Based on this study, it seems more appropriate to use the GIS method as a first step to identify priority targets while affording some flexibility to the decision makers. Its applications should not be the core method to make strategic decisions but it should remain an instrument to help highlight the most evident solutions and eventually provide backup to an initial plan of action. A map is often worth a thousand words.

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