UNIVERSITY OF COPENHAGEN

Master of Disaster Management

Master's thesis 2019

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Enabling the Implementation of Drones into Local Disaster Preparedness

Key considerations from challenges and lessons learned in Chile

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Submitted: 05-12-2019

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Abstract

Combining the need for local capacity development and ownership in disaster risk management (DRM), with the opportunities presented by more accessible drone technology, this study seeks to understand and assess the barriers for the implementation of humanitarian drones into local disaster preparedness. While drone technology is becoming more easily accessible as prices drop and the technology becomes more user-friendly, drones are often utilized only in the event of a disaster, as they are managed by international organisations or private actors. By building national and local capacity and integrating drones into DRM processes and protocols, the use of drones can be tailored to the risks and needs in the local context and they can be used in reducing risks and increasing preparedness. Through a field study in Chile to identify key benefits and challenges of drone implementation from lessons learned, triangulated then with experiences from other actors and countries, this exploratory research project identifies a potential for drones in current disaster preparedness in Chile, however current barriers for drone implementation need to be considered and addressed for drones to effectively be implemented into local disaster preparedness efforts. These barriers relate to the enabling environment, capacities and access, such as integration of drones into national and local DRM frameworks and protocols, adequate allocation of resources, mitigation of technological limitations, increasing network of drone practitioners for adequate geographical coverage and improving capacity development.

Acknowledgements

This research was supported by the non-governmental organisations WeRobotics and Chile Flying Labs. I thank in particular the coordinators of Chile Flying Labs at Universidad Bernardo O'Higgins in Santiago, Chile, for their support in conducting the field study and for providing their insights, expertise and lessons learned from drone implementation in Chile. In addition, I thank the interviewees for their participation, which provided essential insights for the study. The organisations interviewed include:

- DroneSAR Chile
- Oficina Nacional de Emergencia del Ministerio del Interior, Chile (ONEMI)
- Instituto Geográfico Militar Chile (IGM)
- American Red Cross
- Chile Flying Labs volunteers
- Naxa Pvt. Ltd (Coordinator of Nepal Flying Labs)
- The University of the South Pacific (Coordinator of South Pacific Flying Labs)
- Remote Area Medical Philippines (RAM-Ph) and SRDP CONSULTING INC (Coordinators of Philippines Flying Labs)

Abbreviations

DGAC	Dirección General de Aeronáutica Civil, Chile
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
GIS	Geospatial Information Systems
IGM	Instituto Geográfico Militar Chile
NGO	Non-Governmental Organisation
ONEMI	Oficina Nacional de Emergencia del Ministerio del Interior, Chile
UAV	Unmanned Aerial Vehicle
UNISDR	United Nations Office for Disaster Risk Reduction

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1 Introduction

Combining the need for local capacity development and ownership in disaster risk management, with the opportunities presented by more accessible drone technology, this project intends to assess the barriers to implementing drones into local disaster preparedness in Chile by understanding the benefits and challenges of current drone implementation efforts.

Chile is exposed to a variety of natural hazards, including earthquakes, tsunamis, wildfires, floods, landslides and volcanic eruptions. Located in the Pacific Ring of Fire, Chile is considered one of the countries in the world that most frequently experience earthquakes, tsunamis and volcanic eruptions. In addition to being a multi-hazard context, many of the major cities in Chile are located in zones of recurrent hazards. In total 54% of the population in Chile are exposed to three or more hazards. From 2008 to 2018 more than four million people in the country was affected by hazards, with close to 800 deaths reported. (Cecioni & Pineda, 2009; Center for Excellence in Disaster Management & Humanitarian Assistance, 2017; Bronfman, et al. 2019) The earthquake and following tsunami in 2010 caused the death of 562 people and resulted in accumulated material costs of more than USD 30 billion. The recurrence of multiple hazards combined with the risks of loss of life, affected communities, and economic and material losses, emphasize the need for efficient and effective preparedness strategies for disaster risk reduction. (Bronfman, et al. 2019)

Disaster risk management (henceforth referred to as DRM), refers to the planning, policies and actions taken to reduce the risks of hazards in terms of material, environmental, financial damages and losses, and loss of life (UNISDR, 2009; GDPC, 2017). As one of the four main phases of DRM, *disaster preparedness* is essential in mitigating the risks and impacts of natural and man-made hazards. The preparedness phase deals with the knowledge and capacities of all actors, including governments, organisations, communities and individuals, to effectively and efficiently manage all types of emergencies for a sustainable recovery. Disaster preparedness is implemented through activities such as disaster risk analysis, monitoring of potential hazards, vulnerability and capacity assessments, contingency planning, early warning systems, logistics, trainings and field exercises to test response actions. (UNISDR, 2008; UNISDR, 2009; IFRC, 2019; European Commission, 2019). As many natural hazards are predictable and recurrent, disaster preparedness programs can be cost-effective solutions to DRM. By implementing risk management and capacity development for hazard mitigation and early action in vulnerable communities, preparedness should increase the resilience

and readiness of these communities and decrease impacts on lives and livelihoods (UNISDR, 2008; European Commission, 2019).

Technologies, such as robotics, offer great potential in DRM, in particular in relation to savings in cost, time and human resources (Guardian, 2017; Tanzi, et al. 2016). Previously used primarily for military purposes, humanitarian drones (or unmanned aerial vehicles (UAVs)) are now becoming increasingly useful as a tool in all phases of DRM (preparedness, response and recovery) (FSD, 2016; OCHA, 2014). Though drone technology is becoming more easily accessible as prices drop and the technology becomes more user-friendly, drones often arrive too late in the event of disasters, as they are managed by international organisations or private actors. A way to address this issue is by building local capacity and integrating drones into DRM at local level. (FSD, 2016) With local capacity development, the use of drones can be tailored to the risks and needs in the local context and used not only in the immediate aftermath of a disaster, but also where relevant in increasing preparedness of the communities and reducing risks.

In 2015, as the first country in Latin America, Chile introduced regulations making drone flights legal (SpaceWar, 2014). While drones are now being used for commercial and industrial purposes such as in the mining industry in Chile (DroneBelow, 2018), drones are yet to be formally integrated into national DRM frameworks and as such is not mentioned directly in the national strategic plan (ONEMI, 2016). However, non-governmental organisations (NGOs) like DroneSAR Chile and Chile Flying Labs are driving the efforts in Chile to integrate drones into DRM approaches. In 2017, during the large-scale forest fires, DroneSAR partnered with the forestry and fire brigades and became responsible for the first ever drone use in a major emergency operation in Chile. This led to an official agreement between DroneSAR and the Chilean government, allowing for the fire departments to use DroneSAR drone equipment and expertise for search and rescue and fire suppression missions. This agreement has been a steppingstone for drone integration in other government departments and operations as well, where drone integration is now being looked into also for planning and environmental services. (DJI Enterprise, 2019) With the government funded Research Center for Integrated Disaster Risk Management now focusing more of its research on the use of drones in DRM (CIGIDEN, 2019) and with NGOs pushing for inclusion of drones in national DRM frameworks, it does not seem unlikely that we will see drones integrated further into national frameworks and

protocols for DRM. However, time will tell if this includes local capacity development in the use of drones for disaster preparedness.

1.1 Research objective

While much research has been done on the inclusion of local actors in DRM, in particular in the light of *The Grand Bargain* coming out of the 2016 Humanitarian Summit (United Nations, 2016; L2GP, 2016; OECD, 2017), and on the use of drones in relation to DRM (e.g. Tanzi, et al. 2016; Leetaru, 2018), the potential and barriers in implementation when it comes to combining these have received limited attention in research and is currently primarily presented through grey literature, as case studies from international and NGOs (e.g. FSD, 2016; Schroeder, 2018). Through explorative research with a field study on the implementation of drones into local disaster preparedness in Chile, triangulated with knowledge and lessons learned from other actors and countries, this research project aims to start filling the current research gap by providing new research and initial insights into key challenges and barriers for drone implementation at local level.

Research Objective

To understand and assess the barriers to implementing drones into local disaster preparedness in Chile.

Specific research questions

- How are drones implemented into national and local disaster preparedness in Chile?
- What are the benefits and challenges when implementing drones into local disaster preparedness in Chile?

2 Methodology

The thesis was conducted as exploratory research through a qualitative field study with participatory observations and interviews in Chile, as well as online consultations, combined with a desk study to understand key concepts and general trends of challenges and considerations when implementing drones for local disaster preparedness. The findings from the field study will be discussed to assess the identified challenges and propose key considerations for future implementation of drones for local disaster preparedness.

2.1 Desk Study

Prior to entering the field, a desk study was conducted to ensure appropriate background knowledge of existing literature, concepts, theory and practice, as well as the context of Chile as the field study location. The desk study focused on:

- Disaster Risk Management (DRM) and disaster preparedness
- The use of humanitarian drones for DRM
- Legal frameworks, regulations, clearances and code of conduct for use of drones for preparedness
- The hazard landscape of Chile
- DRM in context of Chile, including policies, planning and legal frameworks

The desk study forms the introduction and conceptual sections of the thesis project.

2.2 Field study

A two-week field study in October was carried out in Chile in collaboration with *Chile Flying Labs*, a part of the global network of drone cooperatives facilitated through the not-for-profit organisation *WeRobotics*.

About Chile Flying Labs

Chile Flying Labs is part of a network of "Flying Labs" around the world as national knowledge cooperatives providing capacity development to local practitioners and communities and access to technologies. At Chile Flying Labs they are focused on improving the preparedness capacity of their country. Run by Universidad Bernardo O'Higgins, the Flying Lab provides training for local actors and organisations in drones and new technologies to improve disaster risk management efforts. In addition to local capacity development, the Flying Lab also focus on facilitating an ecosystem amongst local, national and international actors to integrate drones and robotics effectively into disaster management frameworks and efforts. (Flying Labs, 2019)

Field study location

Based on the preliminary desk study several potential field study locations were considered. Ultimately the decision to conduct the field study in Chile, was decided based on: 1) the hazard landscape and history of Chile, as well as their progressive national disaster management frameworks, including a focus on disaster preparedness; 2) the opportunity to engage through participatory methods with the Chile Flying Labs volunteers and coordinators, as well as government officials and other stakeholders actively involved in the integration of drones into disaster preparedness practices in Chile.

Field study methods

As a qualitative study, the research was conducted through participatory methods. The field study process included convenience sampling and purposeful snowball sampling to determine appropriate stakeholders to engage in the participatory methods (Palinkas, et al. 2016). Initially identified potential stakeholders that have practical experience with the implementation of drones into local disaster preparedness included Chile Flying Labs volunteers, Chile Flying Labs coordinators, DroneSAR Chile, other countries' Flying Labs offices, American Red Cross GIS and drone staff and Chile government offices. Through continued consultations with Chile Flying Labs, opportunities were assessed to conduct focus groups discussions and drone flight observations.

Participatory observations

The month of October, in which the two-week field study took place, is the month of Disaster Risk Reduction in Chile. As such, a series of events, workshops, meetings and trainings took place. Through the collaboration with Chile Flying Labs, participatory observations were carried out at some of these events. Observing these events provided a unique insight into the development of DRM approaches and frameworks in Chile, an understanding of the current national, regional and local discussions around drone use for DRM, and provided opportunities for purposeful snowball sampling to further discuss relevant topics and areas of interest to the study through formal interviews.

Informal qualitative approaches

In relation to the events during the month of Disaster Risk Reduction and observations as described above, informal interviews were carried out leading to further formal interviews and providing

informal insights and triangulation of data to further strengthen the thesis findings. For these informal interactions, probing was used to supplement the question guide (Annex 1).

Interviews with key stakeholders

Through consultations with Chile Flying Labs, formal interviews with key stakeholders from the government, volunteers, drone practitioners, etc. were set up. Some interviews were scheduled before arrival to Chile, other interviews were scheduled through convenience and purposeful snowball sampling while conducting the field research. Formal interviews with other professionals working with drones for DRM were set up to triangulate the findings in Chile. In addition to the on-site field study in Chile, this included a series of online interviews were carried out with relevant Flying Labs from across the globe, as well as an interview with a representative of the American Red Cross with extensive experience in drone implementation and capacity development for DRM. The Flying Labs were selected based on their experience and involvement in drones for DRM, in particular disaster preparedness. For all formal interviews, probing was used to supplement the question guide (Annex 1).

Concrete activities conducted

Table 1: Activities conducted

	Activities conducted
Observations	• Drone mapping (Aculeo Lagoon, drought) • Drone mapping (Valparaiso, forest fires) • National Early Warning Centre of ONEMI • National Seismological Centre • Meeting on drones for radioactive monitoring • Event on geomatics and cartography with attendance of academia, government, military, navy and air force officials
Interviews	• DroneSAR Chile pilot • Chile Flying Labs volunteers • Chile Flying Labs coordinators (specifically Universidad Bernardo O'Higgins) • Oficina Nacional de Emergencia del Ministerio del Interior, Chile (ONEMI) (Chile's National Emergency Management Authority) • Instituto Geográfico Militar Chile (IGM) (Military's Geographical Institute Chile) • American Red Cross GIS and Drone expert

	• Naxa Pvt. Ltd (Coordinator of Nepal Flying Labs) • The University of the South Pacific (Coordinator of South Pacific Flying Labs) • Remote Area Medical Philippines (RAM-Ph) and SRDP CONSULTING INC (Coordinators of Philippines Flying Labs)

2.3 Limitations of the study

Limited amount of existing research is available specifically on the use of drones for local disaster preparedness. In addition, there is currently limited monitoring and evaluation of the capacity building of local practitioners in the use of humanitarian drones for DRM and preparedness, as well as a lack of research on the barriers for local drone implementation to complement the field study findings. As the thesis project aims to help fill in this research gap, the study triangulates the data collected through the field study in Chile with online interviews with other drone practitioners in different contexts.

The exploratory study is intended as preliminary research to urge for further research into the area of drone use in DRM and more specifically for local disaster preparedness and to help facilitate and inform future drone implementation at local level. As such, the study is limited to presenting the findings from the field study in Chile, triangulated with the desk study and additional online interviews, however it will not aim to make any final or generalized recommendations or statements. Further research into the subject of this study should be conducted in order to provide more generalized recommendations.

The field study was planned to take part over the course of 12 days and included additional activities to the ones described above, including focus group discussions. However, due to the State of Emergency in Chile announced mid-October 2019, some planned activities were cancelled as public institutions and infrastructure were closed for security reasons. As such the field study was limited to a total of six active days. This thesis project thus presents the findings of these six days of field study.

2.4 Ethical considerations and guiding principles

As the thesis research was conducted as a qualitative study based on interviews and observations and in collaboration with a partner organisation, the following ethical aspects were taken into consideration and acted upon when relevant and possible:

1) **Informed consent:** Verbal informed consent was obtained from research participants and interviewees prior to their participation in the study.
2) **Confidentiality and data protection:** All data collected through the study will follow relevant guidelines on data protection and confidentiality.
3) **Bias:** It is understood that conducting the field study with Chile Flying Labs may influence the outcome of the study. Such bias is recognized and mitigated whenever possible.
4) **Giving back:** It is envisaged that the thesis project will be complemented by a guest blog article or a webinar to share the research findings with the *Flying Labs* network and other relevant stakeholders globally. In addition, the research will be shared with research participants, including other Flying Labs, DroneSAR Chile, American Red Cross, and government officials.
5) **Participation and equality:** Equal importance are given to the statements and inputs provided by all involved stakeholders. No priority or additional importance have been given to any statements or inputs of certain stakeholder groups or individuals.
6) **Local knowledge:** Whenever possible the study strives to obtain an understanding of the local knowledge, lessons learned, best practices and experiences of local practitioners, to ensure that local knowledge is adequately represented in the study.
7) **Respect:** Every participant of this study and their inputs was treated with the utmost respect and their inputs were documented and considered for analysis. This relates to engagement with all stakeholder groups.

3 Analytical Concepts

3.1 Disaster Preparedness

Disaster preparedness is a cost-effective approach in DRM. As natural hazards are often reoccurring and some predictable, disaster preparedness efforts reduce the risks and impacts of such hazards in advance and if possible, prevent disasters. Disaster preparedness activities focus on reducing risks and increasing coping capacities of individuals, communities, organisations and institutions. Such activities can include early warning, vulnerability and capacity assessments, contingency planning, logistics and capacity development. (Sutton & Tierney, 2006; European Commission, 2019; IFRC, 2019) In particular relevant to this research is the preparedness activities related to hazard

identification, risk assessment, contingency planning, resource management, hazard monitoring, and capacity development, as these are areas where drones can play a role in closing preparedness gaps.

Enabling environment and disaster risk governance

Essential for the effective implementation of disaster preparedness is ensuring an enabling environment at an institutional level. This refers to the structural, or referred to by UNISDR as functional, capacities of the broader system of individuals and organisations involved and relates to policies, legislation, frameworks, procedures and institutional organisation, including ensuring necessary mechanisms and incentives in promoting DRM. The mandates of involved stakeholders are determined through such legislation and formal rules, defining clearly their roles and responsibilities. As such, policies and legislation also contribute to the sustainability of local disaster risk reduction and preparedness efforts, by for instance guiding budget allocation. (UNISDR, 2018; UNISDR, 2019; Valibeigi, et al. 2019)

Furthermore, in addition to the structural capacities, disaster risk governance focused on coordination and collaboration within and across sectors and stakeholder groups determines the effectiveness of implementation. (Jones, et al. 2015; UNISDR, 2018; Valibeigi, et al. 2019) Disaster risk governance may happen in three ways:

1) *Upward* with the inclusion of international organisations, such as the United Nations.
2) *Downward* as a decentralization to local authorities, as much of the responsibility in implementing DRM and disaster preparedness falls with local authorities as the first responders and as the most knowledgeable about their local context, vulnerabilities and capacities.
3) *Outward* with the engagement of NGOs and other non-state actors, such as the private sector. Through engagement with national or local authorities, NGOs often play a role in advocating for policy changes, mainstreaming disaster risk reduction and preparedness, providing capacity building and raising awareness. (Jones, et al. 2015)

Capacity development of local actors for DRM

A key component of disaster preparedness is ensuring community engagement, ownership and capacity development. According to United Nations Office for Disaster Risk Reduction (UNISDR), "*Effective disaster risk reduction requires community participation*" (UNISDR, 2008). Such

engagement is referred to as *community-based disaster risk management* and involves actively engaging potentially affected local communities in the DRM processes, including through community assessments of hazards, vulnerability and capacities, as well as including them in planning processes, implementation of preparedness activities and finally in the monitoring and evaluation of actions. (UNSIDR, 2009)

As hazards, environment, socio-economic and cultural conditions are different from community to community, disaster preparedness and risk reduction should be customized to the local setting. By decentralizing the responsibility of implementing disaster risk reduction and preparedness to the provisional, municipal and local levels, it is ensured that activities are appropriate for the context in which they will be carried out, thereby maximizing risk reduction. In addition, decentralization of preparedness activities and the direct involvement of local actors can motivate local participation, increase ownership and improve the efficiency and effectiveness of preparedness and response. By involving the local actors, it is possible to develop preparedness actions tailored to the local conditions, this includes considering community characteristics of social, cultural, economic, political and environmental nature, as well as building on local knowledge and experience. This ground-up approach should be done through participatory approaches and local capacity development. (UNISDR, 2008; ARC, 2017)

Capacity development plays a central role in community-based disaster risk management and in reducing risks of local areas to natural or man-made hazards. Within the disaster risk reduction and preparedness context, the UNISDR defines capacity as "*the combination of all strengths, attributes and resources available within an organisation, community or society to manage and reduce disaster risks and strengthen resilience.*" (UNISDR, 2009) An organisation's or community's strengths, attributes and resources refer to the capacity of infrastructure, knowledge and skills, institutions, social relationships, leadership and management. By strengthening the capacities of local actors, through training and specialized technical assistance, to recognize and reduce risks and respond to hazards, capacity development builds and maintains peoples, institutions and communities' ability to manage and cope with risks successfully themselves. Such capacity development efforts seek to further strengthen and operationalize the existing strengths, attributes and resources of the actors, such as through sustainable technology transfer, information exchange, network development, skills development. For capacity development to be sustainable, it must be supported by institutions or

organisations that facilitates continued capacity development and maintenance. (UNISDR, 2008; UNISDR, 2009; UNISDR 2019)

To understand capacity needs and resources, and to facilitate capacity development planning efforts, UNISDR groups the capacity of a nation, society or community according to the type and level(s) of engagement. To be effective, capacity development should include a diverse range of capacity types and levels. Capacity types are grouped into *functional* capacities, referring to planning, leadership, implementation, resource management, and *technical* capacities, referring to a subject matter or area of expertise, such as disaster risk management or GIS software. In addition, capacities can be classified as either *hard* capacities, as tangible and visible such as organizational structures, systems, policies and procedures, or *soft* capacities, relating to for instance culture, commitment, learning, analysis, adaptability and flexibility. In addition, the level groups presented by UNISDR determine the capacity development intervention at the systemic, organisational or individual level. (UNISDR, 2019)

3.2 The 4th Industrial Revolution

The 4th Industrial Revolution refers to the new era in human development, which has been enabled through rapid technological advances. This era presents new opportunities for leaders, policymakers and people to rethink development and value creation by harnessing new and emerging technologies, such as drones, geospatial imagery, predictive analytics, blockchain, and augmented and virtual reality. (WEF, 2017; WEF 2019)

Innovation in disaster preparedness

The Sendai Framework for Disaster Risk Reduction (SFDRR) highlights the need for improved access, investments and support for innovations and technology in DRM, focusing on cost-effectiveness and applicability to all phases of DRM. (UNISDR, 2015; Izumi, et al. 2019)

In relation to DRM, the 4th industrial revolution provides opportunities for all phases. In disaster preparedness, new technologies can and are contributing to reducing risks, decreasing costs, and improving contingency and response planning, through facilitating quicker sharing of critical information, and in improving early warning, the understanding of causes of disasters, and situational awareness. (ITU, 2019) Sharing of data through public-private partnerships now allows for improved

coordination and evidence-based decision-making, closing gaps of outdated and incomplete data. In particular these technologies offer opportunities for community-based disaster preparedness, through data sharing and capacity development. (WEF, 2017; ITU, 2019)

However, while these new innovations of the 4th industrial revolution provide opportunities for improved DRM, they also offer challenges to existing policy frameworks and require rethinking of our DRM processes, including coordination and implementation. This includes formal integration of technological innovations into policy frameworks, action plan and protocols, public-private agreements on data flows and technical specifications, and capacity development. In addition to the formal inclusion and consideration of new technologies, the integration requires strong collaboration between actors, including the government, academia, NGOs and the private sector in the implementation. (WEF, 2017; ITU, 2019; Izumi, et al. 2019)

Humanitarian drones

As an example of technological innovation, an unprecedented number of unmanned aerial vehicles (UAVs), also known as drones, are now being integrated into DRM efforts. Where satellites are costly, less timely, presents data sharing restrictions and are subject to visibility issues, drones capture images of higher resolution and are quicker, more flexible, timely and less expensive to deploy and maintain. (Meier, 2018; OCHA, 2014). Literature indicates that drones are mostly used today to provide response assistance, such as for search and rescue and to support damage assessments, carry lightweight cargo to otherwise inaccessible or hard-to-access areas and increase situational awareness. As an example, in 2014 the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) published a policy brief on the use of civilian UAVs in humanitarian settings. The brief outlines the potential of drones in humanitarian response and emergencies, highlighting that developing best practices and guidelines for their use in natural disasters, slow-onset emergencies and early recovery should be an area of focus. (OCHA, 2014) However, drones are also, to a lesser extent, used in disaster risk reduction and preparedness efforts, to map disaster prone areas, carry out risk assessments, environmental and hazard monitoring and to improve early warning systems. (ITU, 2019; FSD, 2016; OCHA, 2014; Griffin, 2014) Here the FSD outlines two core types of drone interventions particularly relevant to disaster preparedness:

1. *Mapping* is the most common application of drones to date, as it is accessible also to non-technical users through lightweight and consumer friendly drones. With the possibility of

attaching a variety of cameras and sensors, drones offer high-resolutions maps for disaster preparedness analysis as a valuable addition to the tradition satellite imagery, or as a cost-effective alternative in particular for local preparedness activities and remote locations where satellite imagery may be obsolete or expensive.

2. *Cargo delivery*, though rapidly emerging in DRM, is still maturing and the necessary drones are not as accessible to non-technical users. Cargo delivery drones are used to access remote or inaccessible areas, where they offer quick deployment of medicine or emergency supplies. (FSD, 2016)

3.3 Policies and regulations in Chile

Chilean DRM framework

Due to its multi-hazard environment, Chile has a variety of laws, institutions and regulatory frameworks informing and guiding its DRM efforts, including its disaster preparedness. At the center of these processes is the Office for National Emergencies and Internal Affairs (Oficina Nacional de Emergencia del Ministerio del Interior, ONEMI), established in 1974, as the primary technical state agency coordinating the National Civil Protection System (SNPC). As part of ONEMI's efforts in DRM, a National Policy for Disaster Risk Management was published in 2014. It serves as the framework for DRR activities in Chile and guides state entities in reducing the risks and adverse outcomes of hazards, through specifying procedures for developing disaster risk reduction and response processes (Center for Excellence in Disaster Management & Humanitarian Assistance, 2017). In 2016, building on this policy, ONEMI released the National Strategic Plan for Risk and Disaster Management 2015-2018 (ONEMI, 2016), providing a basis for concrete disaster risk reduction actions. These actions are categorized within five priority areas (ONEMI, 2016):

- Institutional strengthening
- Strengthening of monitoring and early warning
- Promoting a culture of prevention and self-insurance
- Reducing underlying risk factors
- Strengthening disaster preparedness to achieve an effective response

Throughout the descriptions of its five priority areas, the strategic plan puts clear emphasis on local engagement, including strengthening local capacity for disaster preparedness and response.

Chilean drone laws and regulations

In order to understand the operational considerations and implementation of drones in Chile, it is necessary to first understand the laws, regulations and ethical codes of conducts that guides the organisations. Each country is responsible for their own laws and regulations on the use of drones for DRM (Tanzi, et al. 2016). As such, the Chilean regulations are the legal basis for the procedures, certifications and licenses that are currently in place. In addition, this section will introduce the Humanitarian UAV Code of Conduct as a current internationally developed ethical framework for drone integration that guides ethical considerations in the implementation of drones in Chile.

In the case of Chile, the designated authority responsible for drone laws and regulations is the Directorate General of Civil Aviation of Chile (DGAC). The DGAC outlines the general rules, registration and licensing requirements for using a drone in Chile. (DGAC, 2017; UAV Coach, 2019) In Chile, it is mandatory to register drones before use and obtaining an operating authorization from the DGAC. This means that each drone to be used will need to be separately registered with information, including manufacturer, model, serial number, type of motorization etc. To obtain the operating authorization, also known as a license, from the DGAC one must be 18 years of age, submit proof of theoretical and practical training in the use of the specific drone model, and pass a written exam, which includes components on flight rules and regulations, meteorology and aerodynamics. Both the registration and license must be renewed every 12 months. (DGAC, 2017; UAV Coach, 2019)

Once license and registration has been obtained, the following general rules for operation must be followed (UAV Coach, 2019):

- Drones must be in line of sight and not more than 500 meters from the operator
- Drones must not be flown above 130 meters
- Drones must be flown 20 meter above and 30 meters away from people not participating in the drone operation
- Drones may not be flown at night or in poor weather conditions
- Drones may not be flown in firefighting areas or in sensitive areas, such a government and military facilities
- Drones may not be flown within two kilometres of an airport

- Drones may not be flown in “no drone zones”, such as national parks
- Only one drone may be flown at a time during a drone operation

Humanitarian UAV Code of Conduct

With the rapid emergence of drones in DRM, legal and ethical frameworks are quickly being developed and recognized to ensure proper implementation. At an international level the Humanitarian UAV Code of Conduct was launched in 2014 to ensure the safe, responsible and effective use of drones in DRM. The Code was developed by a network of 60 organisations, called *UAViators*, which includes entities of the United Nations, inter-governmental organisations and NGOs. The Code applies to all practitioners implementing drones in a humanitarian and DRM context. The Code clearly outlines 15 core considerations and explicitly states that drones should only be used in a humanitarian context when it is safe and in the best interest of the affected communities, and when it follows the humanitarian principles, in particular *do no harm*. The Code emphasizes that the use of drones should only be done when identified as the most appropriate solution and with the relevant permissions in accordance to international and national law. In addition, sensitivity, responsibility and transparency is urged in operations, ensuring that the environment and conflict sensitivities are considered, as well as data protection. In relation to the engagement of stakeholders, the Code refers to effective multi-stakeholder approaches, including partnerships and engagement of local actors and communities, as well as capacity development. (UAViators, 2014)

In 2015, guidelines were added to the Code to ensure proper consideration of data protection, community engagement, conflict sensitivity and effective partnerships. In particularly relevant to the research conducted in this project, the community engagement chapter of the guidelines identify the need to engage with local actors, build on existing knowledge and assessments, and share information and outputs. (UAViators, 2015)

4 Field Study Findings

The findings from the field study in Chile provide an insight into the benefits, challenges and visions for drones in disaster preparedness at national and local levels in Chile. Particularly clear are the barriers that currently limits the implementation of drones and engagement of local actors. The findings from the interviews conducted during the field study were grouped into sub-categories within

the overall categories of benefits, challenges and visions. The specific findings of each sub-category are outlined in this chapter.

Table 2: Field Study Findings

Potential / Benefits	Challenges / Limitations	Vision
Versatile tool **Resource management in emergencies** (timely, quick, efficiency of response planning, evacuation, human and economic resources) **Emergency planning and monitoring** **Update of maps** **Supplementary to satellite imagery**	Drones in formal **DRM frameworks and protocols** **Resources** – e.g. costs, time availability of volunteers; operational infrastructure/ mobility/transport (access to emergencies) **Trainings/capacity:** Spread of volunteers across the country; Split capacities (drone pilots, data experts) **Technical**: batteries, weight, cameras, processing	**Coverage:** Pilots/volunteers across all of Chile Inclusion in **DRM frameworks and protocols** Increased **resources** allocated Better **training** to be able to respond to all types of emergencies **Updated maps**, e.g. for local governments, risk maps for planning (vulnerabilities + exposure) **Environmental monitoring** and anticipation of disasters (e.g. agriculture)

4.1 Drone implementation context in Chile

Prior to understanding the benefits, challenges and vision of drones in Chile, it is important to understand the role of the interviewees in the current drone implementation context – who are the actors, what are their roles and how do they collaborate. The following table with descriptions of actors, roles and responsibilities is derived from the observations and interviews conducted throughout the field study.

Table 3: Actors, roles and collaboration

Entity	Imagery	Role	Collaboration
ONEMI	User	***National Emergency Management Authority*** ONEMI is the official national entity responsible for disaster risk management. This includes preparedness, response and recovery.	Obtains satellite imagery from IGM and on request from drone organisations, such as DroneSAR, with whom they have had collaborations since 2017.
IGM	Provider	***National Geographical Institute*** As the Military's national geographical institute, IGM is the official entity in Chile responsible for the provision of maps and imagery to government and military entities.	Supports the ONEMI and other government agencies with relevant maps and imagery, primarily obtained through satellite, for DRM purposes.
DroneSAR Chile	Provider	***Drone implementation organisation*** DroneSAR consists of volunteer drone pilots, who are certified and licensed to operate in Chile. Drone pilots range from hobbyists to former military, air force or government officials.	Supports the government agencies, including ONEMI, and local authorities in the application of drone technology for all phases of DRM. DroneSAR work closely with Chile Flying Labs on the planning and implementation of drone missions, for which DroneSAR supplies drone pilots.
Chile Flying Labs	Provider/ User	***Drone and GIS collaborative*** Coordinated by Universidad Bernardo O'Higgins, the Chile Flying Labs mobilizes GIS specialists on a volunteer basis in drone analysis and assessments for DRM	Works closely with DroneSAR on the planning and implementation of drone missions, for which Flying Labs provides geospatial analysis and assessments on the basis of drone maps from DroneSAR. Conducts capacity development workshops in collaboration with DroneSAR. Provides ONEMI and other government agencies, including local authorities, with relevant drone data, geospatial analysis and assessments when relevant.

4.2 Potential and benefits of drones for Disaster Preparedness

Drones as a versatile tool

Several interviewees consider drones as a versatile tool for disaster management. They can be used in all phases of DRM and for many types of hazards, as they can be outfitted with different cameras and sensors depending on the specific needs. Examples in the case of Chile through Chile Flying Labs and DroneSAR include drone missions conducted or planned for preparedness and environmental mappings, post-disaster assessments, support with real-time drone imagery during response, contingency planning and monitoring of annual religious pilgrimage, and radioactive monitoring.

Updating maps and providing baseline data

In the preparedness phase, it was emphasized that drones can play a critical role in closing the gap of vulnerability and risk mapping in Chile. In particular an overview of vulnerabilities, risks and assets, such as essential infrastructure, in hazard-prone areas are considered to be lacking in Chile. While hazard maps are available with government agencies, the overview of potential levels of a disaster based on areas of risk and vulnerabilities are currently unavailable. Through the deployment of drones prior to a disaster in identified hazard zones, risk and vulnerability assessments could be done to provide up-to-date baseline data and strengthen the knowledge base for effective and timely response.

In Chile, drone imagery is seen as supplementary to existing accessible satellite imagery. Instituto Geográfico Militar Chile (IGM) is the official entity responsible for the provision of maps and satellite imagery to ONEMI and other governmental institutions for preparedness, planning, response and recovery purposes. However, several interviewees, including IGM and ONEMI, highlight the need for updated maps and imagery. Due to rapid urbanization, infrastructure development and relocation in the aftermath of disasters, maps in Chile are quickly outdated and updating these are subject to funding availability and prioritization. As such, the current implementation of DRM in Chile is largely dependent on outdated geo-information and lack of available vulnerability and risk assessments. While IGM sees the need for updated maps to provide more accurate information for DRM, they currently do not have the necessary resources available to obtain these. In addition, obtaining new satellite imagery in Chile, that is not available through IGM, goes through geospatial organisations based in Argentina, and the processing time and acquiring of such imagery is considered long and tedious. Both IGM and ONEMI recognize the relevance and potential of drones to fill this gap and provide updated maps and in-depth vulnerability and risk assessments for DRM, however

both emphasize the need for political and financial prioritization for the integration of drones into their practices.

Resource management and planning in emergencies

Specifically highlighted by all interviewees, when responding to the questions around the potential and benefits of drones, were the potential of drones to improve resource management in emergencies. This includes improving maps, hazard monitoring, vulnerability assessments, contingency and evacuation planning in the preparedness phase, as well as for rapid needs and damage assessments in response. Through increased preparedness and visibility of both disaster-prone and affected areas, including the possibility of real-time information, drones are seen as a potentially value-adding resource management tool, that can significantly improve the efficiency of response planning and implementation. By using drones, the actors interviewed in Chile aim to improve planning processes and effectively reduce human and economic resources deployed in disaster response. Examples observed and provided by interviewees include forest fires in coastal city of Valparaiso and earthquake response, as well as hazard monitoring, and vulnerability and risk mapping.

4.3 Challenges and limitations of drones for Disaster Preparedness

Resource limitations

While all interviewees see areas of potential value-add of drone implementation in DRM and particularly disaster preparedness, including response planning, resource availability tend to determine their individual level of integration of drones into their DRM processes.

Resources highlighted by interviewees not only refer to the cost of drones and funding availability, but also to human resources and operational mobility and access to emergencies. While more and more drones are now commercially available in Chile for DRM, such as the DJI drones used in DroneSAR operations, the prices of drones are still high for wider use by organisations, in particular considering needs for special sensors and cameras for imagery beyond truecolor (RGB – Red, Green, Blue), such as near-infrared or thermal imagery. In addition, funding allocation for drone integration into DRM, and particularly disaster preparedness, is limited. DroneSAR and Chile Flying Labs highlight the funding restrictions for NGOs and academia in accessing funding for drone operations, while government agencies such as ONEMI and IGM highlight the lack of political support and allocation of financial resources to the implementation of drones into official national protocols and

procedures, including for drone equipment and capacity development. Additionally, as drone organisations, such as DroneSAR and geospatial analysts in Chile Flying Labs, all work on a voluntary basis, their time is considered a valuable resource and a resource that according to both is currently lacking. The implementation of drone activities is dependent on the time availability of these volunteers and for this reason the organisations currently have to be quite selective in their drone missions and assessment projects. As the volunteers are scattered across Chile in an effort to cover as many of the country's regions as possible, it is sometimes difficult to ensure timely access of volunteers to emergencies, as they often have to travel far, have access to their own vehicles, and public infrastructure may be limited or obstructed in affected areas. As such, organisations such as DroneSAR, experience limitations in their response capacity due to the access and mobility resources of its volunteers.

Training and capacity development

Aiming to cover as much of Chile as possible the volunteers of both DroneSAR and Chile Flying Labs are spread across the regions in Chile. As such, with many trainings taking place in Santiago, training and capacity development is particularly challenged, and many training attendees are therefore attending the trainings online.

Another challenge of capacity development relates to the current split capacities of actors involved in drone implementation in Chile. While DroneSAR pilots are specialized and certified in flying the drones, they most often do not have the needed analytical and geo-spatial software capacities that are needed to process and analyse the collected imagery and data. The data is instead currently being analysed by GIS volunteers, specialized in the use of GIS software, however these analysts do not have drone flight capacities and are not certified pilots. Additionally, both drone pilots and GIS volunteers sometime lack DRM specific knowledge and a common terminology.

Technological challenges

While resources and capacities can be mitigated by the organisations and authorities in Chile themselves, other challenges are externally generated and relates to the technical functionality of the drone technology itself. Highlighted by the interviewees are in particular three technological challenges:

- Battery capacity: According to the interviewees, battery time is currently limiting drone flights to around 20 minutes per battery, as such DroneSAR requests its pilots to carry six batteries for every drone mission.
- Camera functions: The standard commercial drone comes with a truecolor (RGB) camera, which can capture high resolution images and video. However, for some assessments in disaster preparedness, there is a need for more advanced sensors, such as infrared and thermal imagery. These sensors come with additional costs to the drone organisations.
- Processing time: Drone imagery, due to its high resolution, requires a lot of processing power, which in turn means that processing of the imagery often takes a long time. As such, the processing is currently a limiting factor in drone implementation in delivering quick and timely analysis and assessments.

Drones in formal DRM frameworks and protocols

As drones are still quite new to Chile, having been introduced only a few years ago with the launch of DroneSAR Chile, there are currently no formal integration of drones into national DRM frameworks and protocols in Chile. The engagement of drones into disaster preparedness and response efforts is instead happening on an ad hoc basis, either due to local authorities, police, military and fire brigade actively engaging drones independently and through their own budgets, or through the offering of drone support and imagery by DroneSAR and Chile Flying Labs. As such, with no structured approach to the inclusion of drones, organisations, such as DroneSAR and Chile Flying labs, are limited from supporting national and local disaster preparedness efforts in a structured manner and are not part of the formal contingency planning or preparedness efforts. Therefore Chile Flying Labs and DroneSAR are collectively implementing a two-tier approach of working with ONEMI and other public entities, such as local authorities, the police and fire brigade to increase the awareness of drone potential in Chile and integrate drones into formal action plans and response protocols, while simultaneously increasing the capacity development and strengthening of drone presence in Chile.

In addition, current regulations present challenges to the implementation of drones. For instance, regulations require 15 days advance notice for drone operations, when not related to an emergency situation, and drone certification can only be obtained through physical attendance at an official air force base.

4.4 Vision of drones for Disaster Preparedness

As part of the field study, interviewees were asked to share their ideal scenario for drones in disaster preparedness in Chile. Based on their responses the consolidated vision for drones in Chile include:

- **Geographical coverage**, through increasing the number of certified drone pilots and GIS analysts across all regions in Chile, allowing for local implementation of drones in all phases of DRM.
- **Improved training** to be able to respond to all types of emergencies and ensure a common terminology and understanding of DRM, including vulnerabilities and risks, across involved stakeholders.
- **Updated maps** for local authorities and public entities, going beyond hazard mapping and including risk maps of vulnerabilities and exposure to enhance preparedness planning and response efforts.
- **Inclusion into DRM frameworks and protocols** to allow for systematic, structured and coordinated implementation of drones in all phases of DRM in Chile at national and local levels.
- **Broadening the scope of drone use in Chile** to environmental monitoring and anticipation of disasters, for instance in relation to agriculture through the monitoring of vegetation and crops.
- **Increased resource allocation**, as highlighted by all interviewees, funding is a major barrier in achieving the above components of the drone vision. As such, unlocking financing for drone integration and implementation is seen as a key enabler of the vision.

After offering a vision for drones, they were asked to outline the key barriers in implementing their vision. The outlined barriers fed into the section above on challenges and limitations and helps guide the discussion chapter.

5 Discussion

The findings from the preliminary desk study, the field study in Chile and the triangulation of data through online interviews with drone actors active in other contexts, identified a range of key

challenges and barriers for drone implementation into local disaster preparedness. From this, thesis discussion aims to derive key considerations from lessons learned in Chile and present these in relation to other contexts, in order to support future implementation of drones in local disaster preparedness.

5.1 The relevance of drones for disaster preparedness

Based on interviews in Chile, as well as with Flying Labs coordinators from private sector and academia in other countries (Fiji, Nepal and Philippines), and the American Red Cross, key areas of relevance for drones in disaster preparedness have been identified.

Drone imagery

According to interviewees, traditional sources of aerial imagery for assessments and decision-making are often expensive, takes time to obtain, may not be of the exact relevant geographical area, and is subject to interference from weather conditions, such as clouds. With quick deployment, low costs and interchangeable sensors, drones offer an alternative or supplement to traditional satellite and manned aircraft imagery, in particular for smaller scale and local disaster preparedness. In addition, drones offer high-resolution imagery with a resolution down to 2cm. The increased level of detail offered by drones, versus for instance free satellite imagery with a resolution of 10m, allows for more detailed assessments. As such, drones offer a potential solution to currently outdated maps of hazard prone areas, in particular in local areas where resources are not available to obtain updated and high-resolution maps from satellite organisations or in areas of rapid urbanization, development or other landscape changes, e.g. due to recurring hazards, as traditionally obtained imagery gets quickly outdated in such areas. Here drones can replace traditional imagery and quickly deploy to ensure up-to-date situational awareness and assessments.

Assessments, planning and resource management

In countries, such as Chile, focus is placed by the government at national and local levels in particular on hazard mapping and evacuation planning for disaster preparedness, however vulnerability and risk assessments may not be available. By deploying drones in hazard prone areas, it is possible to effectively map community assets and exposure, and thereby understand areas of particular vulnerability and risk. By providing access to high-resolution maps and vulnerability and risk assessments, drones may be a relevant tool in improving contingency planning and other preparedness

activities, such as local capacity development, to increase evacuation, early warning and coping capacity of communities. In addition, in particular for response planning, such drone maps and assessments can improve resource management in the event of a hazard, as situational awareness is improved and knowledge of vulnerabilities and risks helps prioritize resource allocation and deployment, e.g. to areas identified as particularly vulnerable or at risk.

Local interventions

The relevance of drones becomes particularly clear in local and remote or inaccessible areas, where assessments are not of priority for national disaster preparedness processes. Here preparedness planning and disaster risk reduction activities are sometimes based on outdated maps and thereby with limited overview of populated areas and community assets. Engaging drones through local actors, such as local authorities or organisations, local communities will be equipped with essential knowledge to improve their disaster preparedness.

In addition, drones offer a democratization of data collection by putting the power in the hands of the user, in terms of deciding areas of focus for preparedness efforts. As highlighted by UNISDR (UNISDR, 2008; UNISDR, 2009; UNISDR, 2019), engagement and capacity development of local actors is essential in effective disaster preparedness and drones offer an entry point for this, that allows for local actors and communities to identify and respond to their specific needs in relation to disaster preparedness.

While the research highlights the relevance of drones in disaster preparedness and provides an understanding of the potential benefits in particular for local level interventions, a range of barriers currently exists and must be addressed for the potential of drones to be realised. This includes ensuring that an enabling environment is in place, institutionally and structurally, and increasing the accessibility of drones for local actors.

5.2 Creating an enabling environment

In Chile, the enabling environment and effective disaster risk governance for drone implementation, in particular at local level, is yet to be formally established. This relates to what UNISDR identifies as hard functional capacities at systemic and organizational levels in Chile. (UNISDR, 2019) As such, local authorities and other stakeholders do not have the appropriate policies, frameworks and

procedures in place, and as such also lack funding, to guide the integration and appropriate implementation of drones for DRM and specifically disaster preparedness. Until such enabling environment, with clear disaster risk governance for drone implementation, is formally established, drones will continue to be implemented on an ad hoc basis and whenever local authorities, police or fire brigade independently engage with organisations such as DroneSAR and Chile Flying Labs.

Formal facilitation of drones

With an existing DRM framework, including policies, action plans and protocols, and a long history of dealing with hazards and disasters in Chile, there are existing entry points for formal drone integration in Chile. As an example, the *National Strategic Plan for Risk and Disaster Management 2015-2018* (ONEMI, 2016) provides a basis for concrete actions in disaster risk reduction within which drones could be integrated. In particular opportunities exists within three out of the five priority areas related to monitoring and early warning, underlying risk factors, and disaster preparedness for effective response. As highlighted through the findings of the field study, drone imagery can play an important role in hazard monitoring, addressing risks and vulnerabilities, and in improving situational awareness and contingency planning for response planning and resource management. In addition, with its emphasis on local engagement and strengthening of local capacities, the strategic plan provides an opportunity for local level integration of drone technology and development of related functional and technical capacities.

The entry points for the creation of an enabling environment for drones in local disaster preparedness seems to vary from country to country, depending not only on the existing level of the country's DRM framework, but also on the existing or non-existing legislation and regulations on drone use. Regulations impact and shape the engagement by determining who, when and where drones may be used. Where drone regulations in Chile, similar to the Philippines and Fiji (through Australia), allow only certified drone pilots to operate drones with a permit for disaster preparedness with a processing time of approximately 15 days, other countries have less extensive drone regulations. In some countries, such as Nepal, drone certifications are given on the basis of only a written test and no proof of practical training or practical test, allowing for easier access to drones for local practitioners. These different levels of regulations determine the way drones are implemented at local level by organisations in a country. While organisations in countries with less restrictive regulations may focus on training local communities and students as local drone practitioners, other countries, like Chile,

with more strict regulations, permits and certifications are limited to focusing on internal organisational capacities of the NGOs with professional pilots or volunteer pilot programmes and on building the capacity of local authorities and other public practitioners, such as the police and fire brigade. As such, the different approaches to implementation of drones for local disaster preparedness, and DRM in general, from country to country can be seen as a result of the level of enabling environment in the country.

Financing drone integration

A current gap, consistently repeated by stakeholders in Chile and other countries, relates to the current lack of funding and government budget allocations for drone integration in DRM, and in particular for disaster preparedness efforts. In order to bring drones to the local level funding is necessary to support capacity building, certification processes, the procurement of relevant drones, batteries and sensors, and insurance.

While some local authorities, police and fire brigades in Chile have independently allocated budgets to the integration of drones into their disaster preparedness or response activities, this is still on an ad hoc basis. As there, due to the lack of formal integration into DRM frameworks, procedures and protocols, are no formal budget allocations for drones in disaster preparedness. Even with formal integration of drones, decentralization of responsibilities in DRM are often not matched with the appropriate transfer of financial resources to the local level, and as such it may be continuously necessary to identify other sources of funding for drones in local disaster preparedness. (UNISDR, 2018) Essential to this process will be to calculate and communicate clear costs and benefits of drones in DRM to external donor organisations. Linking the cost-benefits of drones in DRM with the international agenda on local engagement, through capacity development of local authorities, volunteers or communities, could be an entry point for mobilizing external resources. In addition, lessons learned from Nepal, Fiji and the Philippines, show successful collaboration with private sector entities through Corporate Social Responsibility (CSR) initiatives. In both Nepal and the Philippines, the Flying Labs cooperatives are hosted by or coordinated with the direct engagement of private sector entities, such as private drone operators.

In summary, drone integration into the formal DRM frameworks, procedures and processes, including in disaster risk governance, as well as increasing the accessibility of drone certification, and engaging

in both public and private resource mobilization, need to be addressed to create an enabling environment for the implementation of drones in local disaster preparedness in Chile.

5.3 Bringing drone use to local disaster preparedness in Chile

While the enabling environment determines the formal integration of drones, the capacity and accessibility of the technology impact the practical implementation of drones for local disaster preparedness in Chile.

Developing local capacity

As discussed above, the approach to drone implementation in Chile is determined to an extent by the existing drone regulations, DRM framework and governance, and as such the focus is primarily on developing the capacity of local authorities, police, fire brigade and local organisations. In other countries focus may be on the capacity of local communities, students and populations more broadly. With local authorities being, in Chile and other countries, tasked with the responsibility for implementing disaster preparedness and DRM efforts in general, they are key to the integration of drones into disaster preparedness.

With continuously evolving technologies, capacity development becomes key to effective implementation. And as such, in order to bring drone use to local disaster preparedness, local capacities within drone technology, piloting and analysis software, such as GIS, need to be developed, as well as knowledge increased on the relevance of drones in disaster preparedness efforts. Holistic approaches to capacity development will allow for more effective integration of drones and reduce the amount of internal human resources needed in local institutions and organisations. For drones specifically, there is a need for drone practitioners at the local level to be trained not only as drone pilots, and certified, but to also be knowledgeable about DRM and disaster preparedness terminology, processes and strategies, as well as to know how to then conduct relevant and appropriate assessments and analysis through GIS tools. As such, in training local practitioners, focusing ensuring a broad range of capacities may address current barriers of split capacities and geographical coverage.

In the vision for drones in disaster preparedness in Chile, it is envisioned to have complete geographical coverage of the regions in Chile to ensure that drones are responding to local needs for disaster preparedness. Broad capacity development, as described above, of not only volunteers of

drone organisations, but also local institutions, such as local government, police and fire brigade, will expand the drone practitioner network in Chile. Addressing the barrier of geographical coverage in this way, may allow also for increased local contextual knowledge. In addition, "training of trainers" programs, currently being implemented by South Pacific Flying Labs in Fiji, may serve as succefull practices for replication, as these programs allow for local capacities to spread and for these to become stable resources in local institutions.

Finally, it is essential for the sustainability of the local capacity development that there is continued support from technical organisations, such as Chile Flying Labs and DroneSAR, to maintain and update capacities, in particular as drones and analysis software are continuously and rapidly evolving technologies.

Addressing technological access and limitations

While technological limitations are current external barriers in bringing drones to local disaster preparedness, such as battery lifespan and processing, affecting quick and timely implementation of drones and analysis, and depending on the assessment requirements increasing implementation costs, these are less actionable areas of intervention for organisations and institutions in improving drone integration into DRM in Chile, as they are dependent on new technological developments.

Developing capacities for drone use at a local level is an essential step in bringing drones to local disaster preparedness, however the implementation of drones is also dependent on access to the technologies themselves, both drones and relevant GIS software. While financing was discussed above as a barrier for implementation of drones in local disaster preparedness, other barriers for technological access also exists, including maintenance of drones and equipment and continuously evolving software solutions. For the sustainability of drones in local disaster preparedness efforts, local drone practitioners will need access to guidance on maintenance of drones and spare parts. In relation to both cost and maintenance, it may also be beneficial to consider this in the procurement of the drones themselves, ensuring that they can be maintained at local level with limited access to spare parts and limited technical knowledge.

With new software solutions emerging and providing solutions to current technological limitations, such as processing time, local drone practitioners will need to continuously develop capacity within

new software, as well as engage in research to determine their applicability and relevance for local disaster preparedness and assessment needs. From a cost and sustainability perspective, open and free software solutions are currently being widely used by drone organisations and private companies in Chile, Fiji, Nepal, the Philippines and by the American Red Cross. This is also an important component in addressing technological limitations. While some limitations may be dependent on external technological advancements, other limitations can be addressed locally through experiments with new technological solutions. An example of this from the American Red Cross is the use of local networks of "mini computers" for image processing, which have successfully reduced the processing time by half. Where 10,000 images may have taken two weeks of processing before, these local networks are now processing the same amount of drone images within one week.

In summary, capacity and access to technologies are currently two barriers, which need to be addressed in order to effectively and sustainably integrate drones in local disaster preparedness. This includes broad and continued capacity development, ensuring both soft and hard functional and technical capacities, and with the rapidly changing technological landscape in the 4th industrial revolutions, continuous engagement in addressing technological limitations.

5.4 Addressing barriers

While the potential for drones to close existing gaps in local disaster preparedness in Chile is there, in particular in relation to updating maps, providing vulnerability and risk assessments and improving contingency planning, currently the enabling environment is not there. As such, in bringing drones to the local level in disaster preparedness above existing barriers should be addressed. Through the discussion, the following barriers and associated actions were identified:

1) **Integrating drones into DRM frameworks and action plans** at national and local level, ensuring appropriate engagement and coordination of drones in disaster preparedness, focusing perhaps on key areas of drone potential for initial integration;
2) **Mobilizing the needed resources to facilitate local implementation of drones**, including through integration in DRM frameworks and action plans, and thereby allocation of resources for drones through national and local public budgets, and through engagement with the private sector;
3) **Making drone use more accessible to local actors**, including in relation to regulations and certifications;

4) **Providing broad capacity development** to encompass drone flight training, GIS software and basic DRM training, as a holistic approach in training NGO volunteers and public actors;
5) **Expanding the drone practitioner network in Chile** for appropriate geographical coverage, including ensuring engagement of local authorities and other public institutions, such as police and fire brigade, as well as increasing the network of volunteer pilots and analysts through NGOs; and
6) **Mitigating, whenever possible, technological limitations** through engagement in technological developments and continued capacity development.

Here, building on lessons learned from different countries and contexts offers insights into capacity development approaches and potential technological solutions. While drone regulations and integration into DRM frameworks and action plans are still in development in most of the countries considered in this project, there are clear similarities between challenges experienced in Chile and these other countries. Some of these challenges have been mitigated in the other countries and can be leveraged as potential practices for enabling local integration of drones in Chile, including in overcoming processing time of drone imagery, making drone certification more accessible, mobilizing resources, such as through private sector engagement, and implementing different local capacity development approaches.

5 Conclusion and Considerations

Through the desk study, field study in Chile and online interviews this research project identified and assessed a series of current challenges and barriers to the integration of drones in local disaster preparedness in Chile. The benefits and potential of drones, as highlighted by organisations and government agencies interviewed in Chile, show opportunities to address current disaster preparedness gaps through the use of drones. However, identified barriers, limiting the potential of drones, need to be considered and addressed for drones to be implemented into local disaster preparedness efforts and effectively close existing disaster preparedness gaps. Identified barriers relate to soft and hard functional and technical capacities of the current DRM system, organisations and institutions in Chile. Addressing these barriers can be categorized as:

- ***Ensuring an enabling environment*** for drones at a local level in disaster preparedness, including integration of drones into national and local DRM frameworks and protocols, improving disaster risk governance, and ensuring adequate financial resources, and;
- ***Facilitating local capacities and accessibility***, including improving the accessibility of drones at a local level, mitigation of technological limitations, improving capacity development and increasing the network of drone practitioners for adequate geographical coverage.

If the identified barriers are effectively addressed, there is an opportunity in Chile to close existing disaster preparedness gaps, in relation to maps, vulnerability and risk assessments, contingency planning and resource management, through the use of drones by local authorities, institutions and organized local volunteers.

Based on the research conducted through this project further research could look into:

- Understanding how drone outputs are used in planning and implementation of DRM by national and local authorities and other stakeholders, focusing on examples of concrete actions taken on the basis of drone imagery, analysis and assessments, and their added value.
- Understanding and assessing successful capacity development approaches for drone implementation in disaster preparedness.
- Assessing private sector engagement in the integration of drones into local DRM and its implications for disaster risk governance.

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Annex 1: Question Guide

Drones for disaster preparedness

- Can you provide examples of what you do in disaster preparedness? How are you using drones in disaster preparedness?
- What are the gaps in terms of disaster preparedness that drones can cover?
- What do you see as the benefits / potential of using drones in disaster preparedness?
- What are the challenges / limitations you experience with using drones in disaster preparedness?
- How are drones perceived in the country? (by population, government, etc.)
- What is your vision for drones in the South Pacific for disaster preparedness? (if you could do anything)
- What are the obstacles to achieve this vision?

Implementation structure

- Who is leading the projects?
- Where are the volunteers based? (geographical coverage)
- Are they drone pilots or GIS experts?
- Who are the drone pilots?
- Who processes the data?
- Who owns the equipment? (drone, computers, software)
- When you do drone mappings – who request these? Who do you work most closely with?

Legal permissions (regulations, permits, certifications, insurance)

- Legal permissions for drone use in the area and for preparedness purposes
    - Do you need any clearances/permissions to use drones for your purpose?
    - How do you get these clearances/permissions?
    - How long does it usually take?
    - Do you need any training or certification to get clearances/permissions?
- Does the legal framework allow for drone use by local communities?

Technology access, costs and maintenance

- How do the practitioners/volunteers get access to drones? / How do you get the drones?

- Does it have any cost to them? Do they pay for it? / How much does it cost to you?
- Who maintains the drones? Repairs them?
- How much does it cost to keep the drones working?
- What about software for GIS/mapping? Which software do you use and how do you get access to this? What about software updates?
- What about the computer needed?

Capacity development

- Do you do any capacity building/training?
- Who is being trained? (organisations, national/local authorities, community members, students)
- Where is the training done?
- What were they trained in?
    - The need for broad capacity development efforts in drone technology, geo-information systems, geomatics, utilization of maps and data for planning and decision-making in disaster preparedness, etc.

Integration into national DRM frameworks

- Is drone use integrated into national DRM frameworks?
- How is local capacity considered in DRM frameworks?
- What about the combination of drones and local capacity development, is there a link there?
- What are the plans for integration and who are pushing for this?
- What are the considerations for and against integrating drones into the DRM framework?
    - Why? / Why not?
- What are the obstacles for integrating drones in DRM frameworks?