Rapid Response Blueprint

Lessons learned from the digital fabrication of crisis-critical items in Ethiopia and Malawi

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Introduction

The rapid global spread of COVID-19 at the start of 2020 resulted in widespread supply chain disruption and extreme shortages of crisis-critical items, including Protective Personal Equipment (PPE). Around the world, the failure of traditional manufacturing to supply critical items gave rise to local, community-driven initiatives using desktop digital fabrication tools to produce supplies. For example, the M-19 Collective in India leveraged digital fabrication to produce over one million face shields[1]. Visière Solidaire and Protege BR achieved similar feats in France and Brazil respectively.

These projects relied on the availability of digital fabrication within the mass market. Although some of these technologies have existed since the 1950s, they were previously protected by patents and only accessible by industry. In the last decade, these tools have started migrating 'from the factory to the desktop' and are now more widely available to non-professionals[2,3].

Today you can find these digital fabrication tools in a variety of non-industrial spaces, from homes, schools, libraries and, community fabrication spaces (otherwise known as makerspaces, fab labs or hackerspaces). That said, there remains a large disparity in the availability of these technologies around the world. In low-income regions, digital fabrication tools are not widely availability despite their potential to rapidly produce potentially life-saving devices. So the question follows: how might digital fabrication be rapidly deployed in low-income regions as part of crisis response? And how might such a response support recovery and long-term prosperity?

What is digital fabrication?

Digital fabrication refers to a set of manufacturing processes that enable the creation of physical objects from digital models created in Computer Aided Design (CAD) software[4]. Popular digital fabrication tools include: 3D printing, laser cutting and computer numerical control (CNC) milling[5].

The proliferation of digital fabrication, alongside the spread of digital communication platforms and infrastructure, have made it possible for geographically dispersed makers to collaborate and co-design using shared design files[6]. The development of Open Source Hardware (OSH) means that digital fabrication projects can be freely shared via the internet[7]. People can access designs developed in one location and locally produce them in another.

Aim and structure of this report

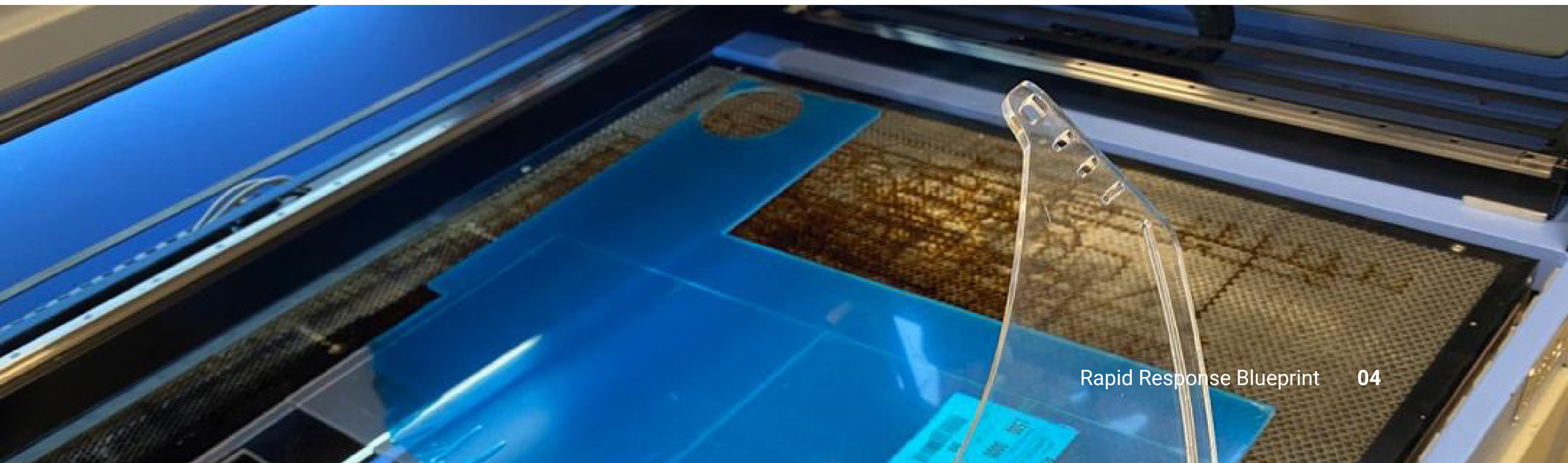
Mobilising a digital fabrication crisis response in regions without existing technological infrastructure requires more than just parachuting in new material and equipment. It involves the complex integration of human, social, infrastructural and financial resources. This report offers a step-by-step guide for how to deploy digital fabrication in a crisis.

It presents a rapid response blueprint, which is based on the experiences of researchers and practitioners working on digital fabrication projects in Ethiopia and Malawi during the COVID-19 pandemic. This guide is particularly relevant for organisations (e.g. non-governmental organisations, research institutions, makerspaces) who would like to implement similar initiatives in other geographical contexts, specifically in – but not limited to – East and Southern Africa.

This report is sectioned in two parts. First, it reports on two cases of rapidly deploying and mobilising digital fabrication to manufacture PPE in Ethiopia and Malawi during the COVID-19 pandemic. Second, it draws on the lessons learned from these projects to present a rapid response blueprint. This rapid response blueprint has been developed using design and systems thinking principles. It provides an easy to adapt template that can be adjusted for different contexts.

Why use digital fabrication to locally manufacture crisis-critical items?

The potential for digital fabrication to produce humanitarian items when supply chains are disrupted has already been reported on[7]. Previous research has shown that digital fabrication is an effective way to meet humanitarian needs, whilst also contributing to the socio-economic development of low-income regions[8,9]. More broadly, it is expected that makerspaces (community workshops equipped with digital fabrication tools) can have far-reaching positive impacts for crisis-affected people: enabling communities to develop items to meet their own needs, as well as supporting community integration, empowerment, education and livelihoods[10].



Digital fabrication of PPE in Ethiopia and Malawi during the COVID-19 pandemic

Background

During the first half of 2020, severe shortages of essential PPE were limiting the prevention and treatment of COVID-19 in Ethiopia and Malawi. Among these items, face shields and face masks were in particularly short supply. In Malawi And Ethiopia shortages were leading to protests from healthcare workers[11,12]. In Ethiopia, a survey of front line workers reported that sourcing these items of PPE was virtually impossible[13].

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At the same time, designs for digitally fabricating these items were being readily shared online. For example, the U.S. National Institutes of Health (NIH) shared designs for a 3D printed face mask on their 3D Print Exchange[14], and the Czech Republic also authorised an respirator mask design made of 3D printed parts and replaceable filters[15]. Elsewhere numerous versions of Open Source face shield designs were being shared, including from organisations such as Prusa[16], Apple[17] and the University of Cambridge[18].

Face masks

Face masks cover the mouth and nose completely, fitting securely onto to the face. There are different categories of face masks and certain types of masks are more effective than others. Cloth masks help reduce transmission while not guaranteeing protection for the user, however some respirator masks are designed to also protect the wearer and are therefore classed as PPE (such as FFP3, N95 masks).

Face shields

Face shields consist of a transparent visor, a frame and a way of holding the face shield in place. Visors curve around the face, and therefore provide the additional benefit of protecting eyes, as well as mouth and nose from droplets.

In Ethiopia and Malawi, design teams were experimenting with ways to locally produce face shields and face masks to meet urgent demand. However the lack of available equipment and tools was preventing them from scaling up production. In response, a collaboration was established between researchers and practitioners based in the UK, Ethiopia and Malawi with support from the Cambridge-Africa ALBORADA Research Fund.

In Ethiopia, the rapid response focused on supporting the development of the **Bahir Dar Institute of Technology (BiT) Makerspace**, in the Business Incubation and Techno Entrepreneurship Center (Bitec). BiT Makerspace had been open for only a few months before the pandemic started, and lacked resources for PPE production. In Malawi, the rapid response worked with researchers from **University of Malawi Polytechnic and iMoSyS**, an engineering services company based in Blantyre. As there was no prior fabrication facility, the rapid response in Malawi aimed to deploy digital fabrication tools and simultaneously set up Twenti Makerspace.

In the short-term these projects are focused on rapidly deploy digital fabrication tools to produce PPE.

In the long-term, the projects aim to foster long-term innovation and entrepreneurship via the development of digital fabrication capabilities in Ethiopia and Malawi.

Figure 2: Face shields produced at BiT Makerspace

What happened next?

Twenti makerspace opened its doors at the beginning of July 2020[19]. The rapid response equipped the space with fourteen 3D printers and a laser cutter. Based on available Open Source Hardware, the team made design adjustments according to local needs and available materials. Just two weeks after setting up the space, 2000 face shields had been designed, produced and donated to two of the largest public hospitals in Malawi: Queen Elizabeth Central Hospital and Kamuzu Central Hospital.

this project provided full time employment for over 25 people

With support from the Ministry of Health Malawi, exemptions were made to the certification of these products. Over 3000 face shields were sold to local SMEs, including: Nico, CADECOM, Eco bank, Royals hotel, MDF, girls empowerment, Blithe construction, Umodzi park, SACCO, BAT. Additionally, over 160 face shields were donated to Chisawani Rural Primary School, Mpemba, Blantyre. Overall, this project provided full time employment for over 25 people for four months, including digital fabrication training for 10 people.

At BiT Makerspace, the rapid response equipped the makerspace with four new printers and one laser cutter, as well as material for PPE production. Over 3000 face shields were donated to Felege Hiwot and Tibebe Ghion Hospital in Bahir Dar, Gonder University Referral Hospital in Gonder and to students' cafeteria workers at the BiT campus. Over 300 face shields were also 3D printed, however issues with quality and certification prevented complete implementation of these items. In total 11 students and 19 academic staff received digital fabrication training during the production of PPE at BiT Makerspace. In recognition of BiT Makerspace's pandemic services, along with other successful projects, the Makerspace was relocated to a larger, more prestigious building by BiT and more staffing resources were allocated to administering the space and its programmes.

Both projects received widespread acclaim in the press and on social media as innovative responses to the crisis that had managed to bypass bottlenecks in the humanitarian system[20,21,22]. This far-reaching coverage has also helped to promote the BiT and Twenti Makerspaces within their local communities. For instance, Twenti has been approached by local organisations for healthcare and engineering solutions. In the future, both BiT and Twenti aspire to provide a platform for aspiring entrepreneurs to develop solutions to local social and sustainability challenges.

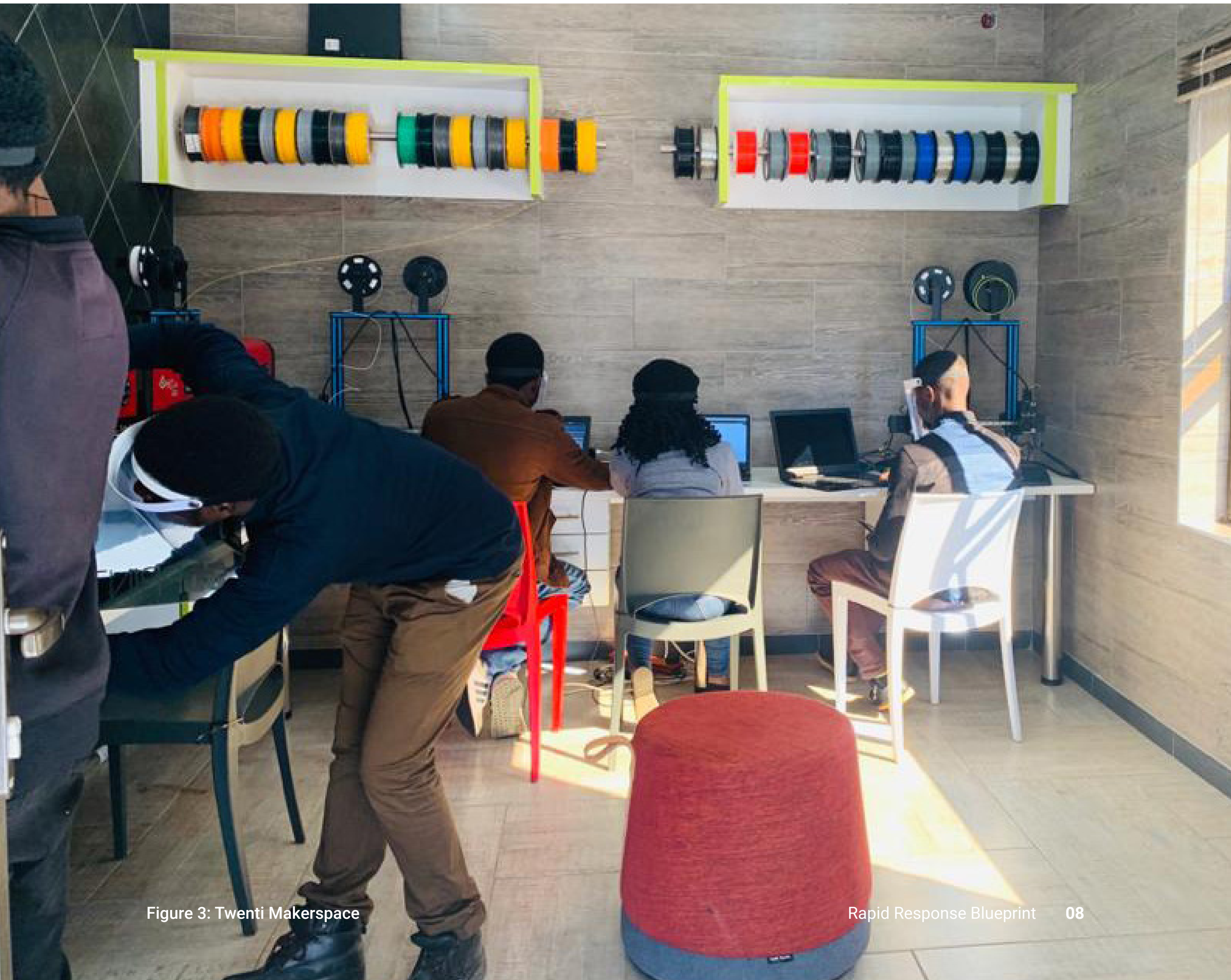

Figure 3: Twenti Makerspace

Figure 4: 3D printing lab at Twenti makerspace

Figure 5: Laser cutting and assembly of faceshields at Twenti makerspace

Figure 6: 3D printed face masks produced at BiT Makerspace

Rapid response blueprint

The rapid response blueprint was developed using a design thinking framework to analyse the iterative stages of crisis management from response, recovery and resilience. This blueprint evolved collaboratively as a result of engagements between researchers at the University of Cambridge, Bahir Dar Institute of Technology, University of Malawi Polytechnic, and the Centre for Global Equality.

Stage 1 : Identify

Stage 2 : Prepare

Stage 3 : Mobilise

Stage 4 : Transition

Stage 1 : Identify

The first stage of a rapid response should build up an understanding of the problem and its particular context. At this stage, teams should map the stakeholder ecosystem to identify short-term and long-term needs, as well as scoping out available resources and current gaps. This stage of the process should aim to clarify why a rapid response is needed.

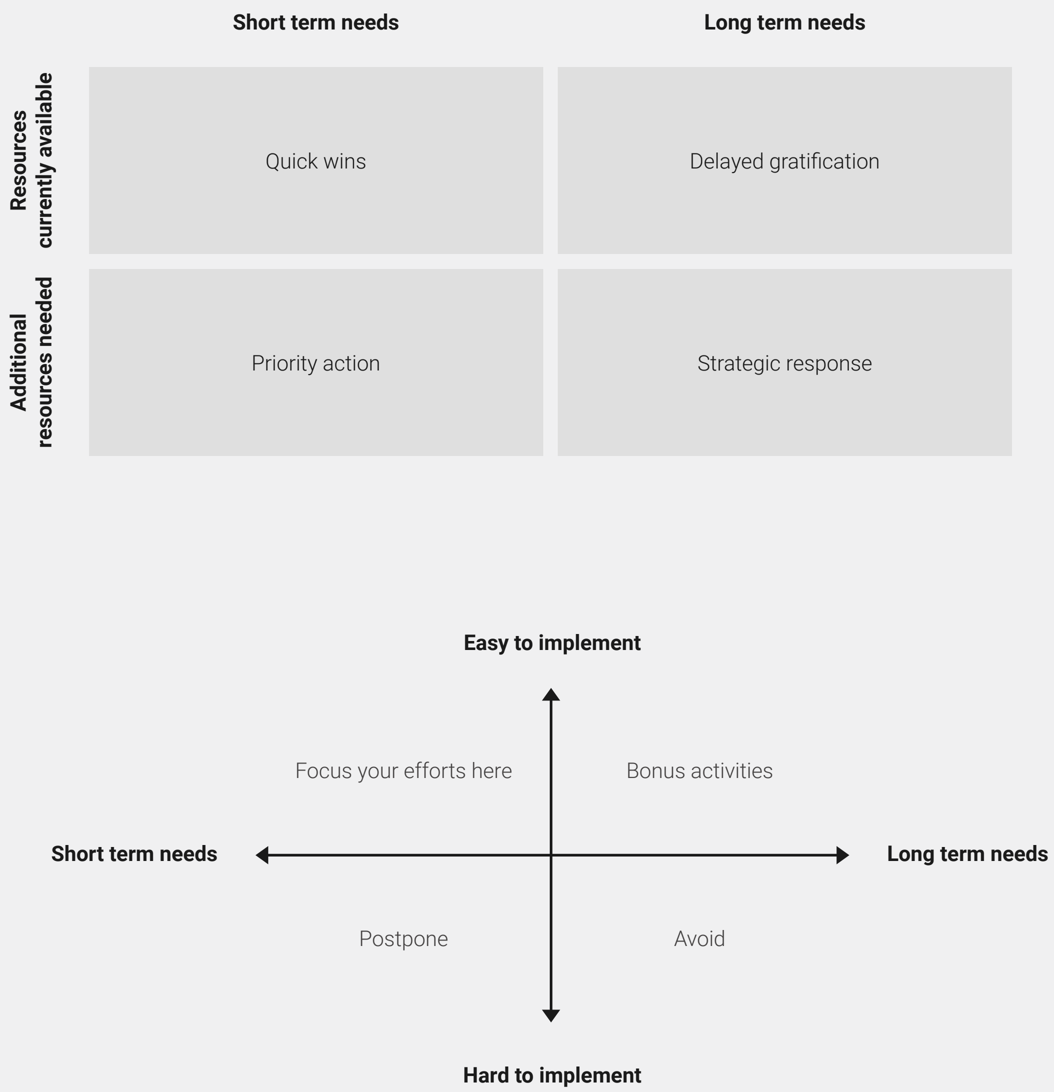

Figure 8: Identifying and prioritising opportunities for a rapid response

Stage 2 : Prepare

This stage aims to outline rapid respond priorities and to lay the groundwork for mobilising a rapid response. At this stage, it is necessary to identify exactly what the rapid response kit will include, and where the rapid response will take place. Key activities include the procurement of materials and hardware, and the preparation of necessary infrastructure.

Where should the digital fabrication facility be set up?

Depending on available infrastructure, the digital fabrication facility might be set up at an existing facility (e.g. a makerspace, fablab or techshop) or an entirely new facility might be established.

Establishing the fabrication facility in a private site may provide more flexibility during the initial stages of crisis response and help to avoid unwanted red tape. However setting up a facility within an existing public organisation (such as a university) may provide additional resources and credibility.

In Ethiopia, the team were already in place at an existing makerspace facility located within a public university so this offered an obvious choice for setting up the project. In Malawi, there was no prior fabrication space available and it was decided to establish the project at a new facility in a private space. This helped to smooth procurement during early stages of the crisis.

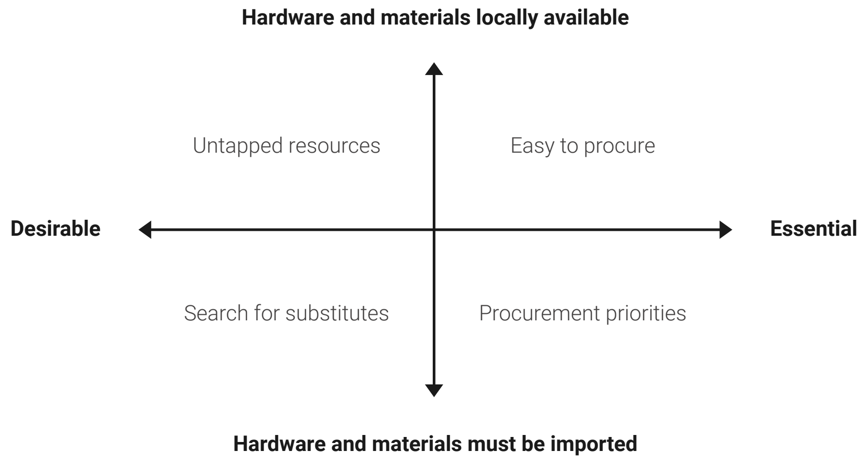

Figure 9: Evaluation of resources required for a rapid response

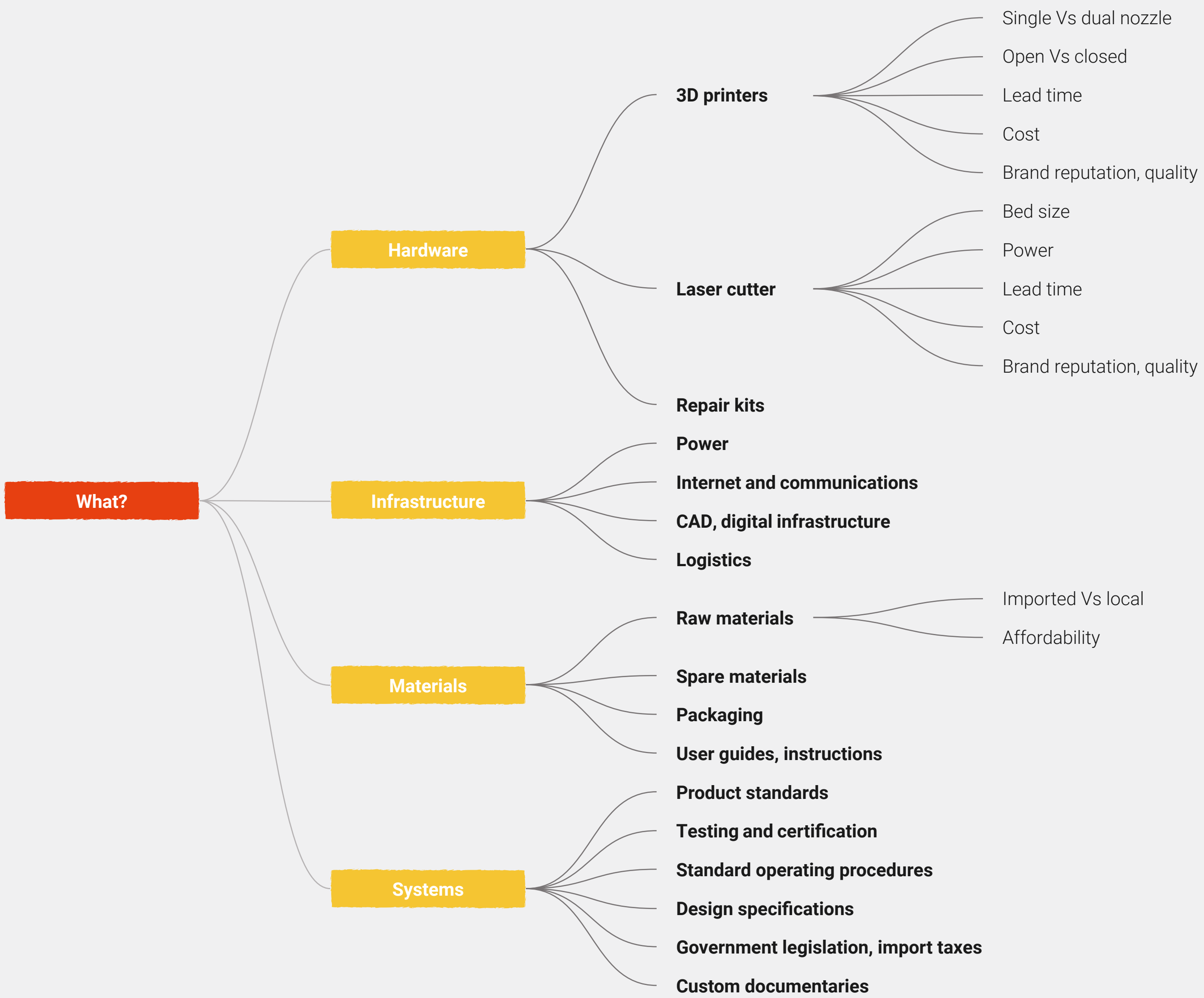

Figure 10: Decision making tree: What hardware, infrastructure and materials are needed? What systems and processes must be followed?

Stage 3 : Mobilise

Once everything is in place, the project is ready for implementation. At this stage ongoing assessment is key to improving and adapting the rapid response. This is especially important as the status of an ongoing crisis may change. For instance, in Malawi and Ethiopia it became clearer as the pandemic unfolded that the demand for face shields was much higher than for face masks.

Figure 11: Twenti makerspace donate face shields to Queen Elizabeth Central Hospital

Stage 4 : Transition

Built into the rapid response is the desire for short-term crisis response to enable long-term recovery and resilience. This stage focuses on the reorganisation of resources and capabilities to focus on long-term community needs. In this phase it may be necessary to recruit additional support, resources and capabilities.

Who needs to be involved and when?

Any rapid response is dependent on the coordination of different actors and the effective exchange of their various resources and capabilities. Actors play different roles during various stages of the rapid response. Figure 11 attempts to capture the different actors who were essential and desirable during different stages of the rapid response in Malawi and Ethiopia. This is not intended to be exhaustive but indicates some of the key actors that should be engaged in similar projects.

Essential (primary role)
Desirable (secondary role)
Disagreement on essential / desirable

	Stage 1 Identify	Stage 2 Prepare	Stage 3 Mobilise	Stage 4 Transition
Project lead	Essential	Essential	Essential	Essential
Institutional champion	Essential	Essential	Desirable	Essential
Clinical expert	Disagreement on essential / desirable	Essential	Essential	Disagreement on essential / desirable
Regulatory expert	Essential	Essential	Essential	Essential
Funder	Essential	Desirable	Desirable	Essential
Partnership building intermediary	Essential	Desirable	Desirable	Essential
Customs liaison officer	Desirable	Essential	Essential	Desirable
Engineers (digital skills)	Desirable	Essential	Essential	Desirable
Low-skilled workers	Desirable	Essential	Essential	Desirable
Policy makers	Desirable	Desirable	Essential	Essential
Local government	Desirable	Desirable	Desirable	Essential
Corporate funders	Desirable	Desirable	Desirable	Desirable
Account fund manager	Desirable	Desirable	Desirable	Desirable

Figure 11: Roles of different actors during stages of a rapid response

Conclusions

For too long, responses to crises have been treated as short-term interventions. These responses have done little to address the underlying conditions that can improve crisis preparedness and recovery. A lack of knowledge sharing has also limited the effectiveness of these responses. This report situates crisis response within a long-term recovery process. It asks: how can crisis be reframed as an opportunity to transition to a more sustainable future?

This report sets out a rapid response blueprint that provides guidelines for how to deploy digital fabrication tools in a crisis. It codifies learnings from two interventions to digitally fabrication PPE in Ethiopia and Malawi during the early stages of the COVID-19 pandemic.

The blueprint identifies four main stages for organising a response (identify, prepare, mobilise and transition), highlighting best practices and methods across these stages.

Overall this study has helped to shed a light on some of the best practices that can be applied in other crisis or geographical contexts. The authors of this study hope that it might help to identify opportunities to combine short-term and long-term actions in an effort to tackle crisis and build more resilient communities.

This report has been prepared by Dr Lucia Corsini, Henok Mebratie Mesfin, Mayamiko Nkoloma, Dr Ndifanji Namacha, Dr Seifu Tilahun, Dr Lara Allen and Dr James Moultrie. It has been kindly supported by the Cambridge-Africa Fund.

Figure 12: Faceshields produced at Twenti being used by hospitality industry in Malawi

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