# Vernacular rehabilitation and rebuilding for post-conflict migration and resettling

Dabaieh, M.; Andriasyan, M.

*Published in:*
International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives

*DOI (link to publication from Publisher):*
10.5194/isprs-archives-XLIV-M-1-2020-901-2020



*Publication date:*
2020

*Document Version*
Publisher's PDF, also known as Version of record



*Citation for published version (APA):*
Dabaieh, M., & Andriasyan, M. (2020). Vernacular rehabilitation and rebuilding for post-conflict migration and resettling. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, *54*(M-1), 901-906. https://doi.org/10.5194/isprs-archives-XLIV-M-1-2020-901-2020

# VERNACULAR REHABILITATION AND REBUILDING FOR POST-CONFLICT MIGRATION AND RESETTLING

M. Dabaieh [1, 2, *], M. Andriasyan [3, 4]

[1] Department of Architecture, Design and Media Technology, Aalborg University, Aalborg, Denmark - mada@create.aau.dk
[2] Departmnet of urban studies, Malmo University, Sweden - marwa.dabaieh@mau.se
[3] Department of architecture, built environment and construction engineering, Politecnico di Milano, Italy - mesrop.andriasyan@polimi.it
[4] Centre of Information Technologies and Architecture, The Royal Danish Academy of Fine Arts Schools of Architecture, Design and Conservation, Copenhagen, Denmark

**Commission II - WG II/8**

**KEYWORDS:** Earthen vernacular, Forced migration, Post-conflict, Rehabilitation, Reuse, Parametric modelling, Algorithmic design, refugee settlement

**ABSTRACT:**

Internal and external migration from vernacular settlements is not a new phenomenon. However, the scale and scope increased when forced migration is becoming exacerbated due to both armed conflicts and climate change. Political tensions are one of the most common threats to vernacular dwellings in conflict areas. Not only do destruction and vandalism cause harm to vernacular architecture, but people living in vernacular buildings are often forced to leave their homes in order to seek safety. On the other hand, vernacular architecture can help refugee crises in hosting countries. Billions of dollars are invested in establishing temporary refugee camps, yet we know for a fact they are rarely temporary. People stay in such camps for decades, commonly Cons located on the outskirts of cities, where vernacular settlements also tend to be. Investments in rebuilding, restoring and reusing vernacular settlements can be a win-win situation. The time and cost of the rehabilitation process might also not be suitable to many camps, or camp-like, contexts. Also, encounters some regulations for listed vernacular heritage sites that cannot be used as dwellings and must be kept as open museums. In this study, a proposal for reusing and rehabilitating vernacular settlements will be discussed together with reflections on challenges and obstacles. The case study chosen for this research is in the Middle East, where the majority of refugees settled after the Arab Spring. This paper demonstrates a methodology in which algorithmic modelling is applied to refugee settlement site planning.

## 1. INTRODUCTION

### 1.1 Study background and problem definition

The increased number of conflicts has resulted in millions of internally and externally displaced people. Thus, there is a dire need for durable housing solutions for affected communities. Addressing these needs is the primary role of humanitarian architecture, a subdomain of architectural and urban planning disciplines. In recent decades there has been much advancement in the design technologies and methodologies put into use in the architecture, engineering and construction (AEC) industry. Namely, computational modelling and algorithmic design. However, this progress has been slower in humanitarian architecture. Despite a few attempts to use cutting-edge technologies and a few research articles, algorithmic planning has not been widely applied to settlement planning for displaced populations.

This case study aims to move humanitarian architecture towards computational modelling and algorithmic design by showing practical applications of algorithmic modelling in refugee camp planning. This proposal is suitable for refugees residing in neighboring countries that share common traditions, social norms and cultural beliefs. Such similarities will make the refugees transition from home countries to host countries easier, with a higher level of acceptance to vernacular housing. This project focuses on Syrian refugees, who, according to UNHCR, are the largest refugee population in the world. March 2020 marked the tenth year of the Syrian Civil War, in which 5.7 million Syrians have been documented as refugees in 127 countries (UNHCR, 2020). The majority now reside in Turkey, Jordan, Lebanon, Iraq, Egypt and other neighboring countries in the Middle East. Ninety percent of Syrian refugees live in highly populated and dense informal areas in which the majority are, unfortunately, dangerous locations (UNHCR, 2020). It is anticipated by UNHCR that at least seventy percent of the Syrian refugee population lack access to basic services like electricity, water and sanitation. Let alone that they live in crowded rooms without privacy (UNHCR 2020; 2018; 2015a).

Vernacular settlements normally offer decent-quality housing, which is not always the case in temporary refugee settlements where tent structures are common. The majority of the time, temporary shelters deteriorate quickly, are ill-adapted to harsh climatic conditions and lack the basics for family life, comfort and protection (Murphy, Ricks 2013). Vernacular settlements can fulfil and accommodate basic social needs for larger families (3+ family members) traditional in the Middle East. Privacy is another major issue in refugee camps which vernacular settlements can accommodate by offering families common spaces for interaction without compromising their personal vulnerability. Rehabilitating vernacular settlements fulfils basic contemporary lifestyle needs. (Dabaieh et al., 2016). It is also hoped that this research can contribute to rebuilding vernacular settlements that have been affected by destruction due to war and political disputes. One of the best

* Corresponding author

ways to preserve buildings is to use them (Feilden 2003; Misra 2009). Similarly, entire settlements are best preserved by keeping them alive with inhabitants instead of allowing them to remain abandoned as ghost towns (Dabaieh 2015). This research aims to offer easy and quick methods for mapping, identifying and evaluating the suitability of transforming vernacular settlements into refugee dwellings while also preserving and rehabilitating their structural and cultural integrity. We hope this study in hand can help in offering practical and hands-on solutions for decision-makers, architects and planners alike that includes housing and infrastructure services.

### 1.2 Literature overview

Creating sustainable housing for migrants is not just a matter of incorporating cultural or social aspects in the planning and construction process, it is also a matter of using materials and developing techniques that will make them environmentally sustainable. Refugee housing is still a big challenge since it regularly turns out to not only be for temporary use (UNHCR, 2014). Internationally, tents are the most commonly used solution, but despite their low cost, they deteriorate quickly, sometimes only lasting for six months (Manfield et al., 2004; Ohlson, Melich, 2014).

Architectural efforts to create sustainable, culturally sensitive and socially integrative designs have recently become a research domain (Barnes et al., 2009; Ohlson, Melich, 2014). Previous experiences with building post crises shelters have revealed that owner-driven concepts for constructing humanitarian shelters yield better results than providing ready-built housing (Aquilino, 2011a, 2011b; Karunasena, Rameezdeen, 2010). However, currently applied processes in hosting countries do not encourage involving refugees in the design or construction process for their homes, nor do they empower people to make their own choices regarding how to live and where (Aquilino, 2011b). Time and cost always hinder for the opportunity to employ participatory building processes.

Providing shelters to solve the urgent need of hosting large numbers of refugees in the shortest time possible is a priority. It is a common belief that the faster the process, the less conflict will emerge (Aquilino, 2011b). However, conflicts also emerge as a consequence of the unsatisfactory outcomes of such housing processes. This is often due to the poor quality of shelters, which are usually not socially or culturally adapted, nor climatically responsive (Dabaieh, Borham, 2015). Several research papers have shown the negative effects of poor integration for the health and welfare of refugees (Phillips, 2006; Schick et al., 2016), while others have shown the importance of connecting post-disaster housing to livelihood recovery (Joakim, Wismer, 2015; Tafti, Tomlinson, 2015). A study by Sadiqi et al. (2017) has shown that a re-established community structure and encouraged sense of housing ownership could be achieved, together with providing disaster recovery support and livelihood opportunities, by applying what they refer to as a 'logical framework' for community capacity building for development activities.

When it comes to energy and performance, Kuittinen and Winter (2015) compared samples from common temporary shelter prototypes. They concluded that shelters built from bio-natural materials have the least impact, with a minimal carbon footprint in comparison to others made from industrial materials (i.e. metal-intensive structures), but there is always a limitation as to the time of construction compared to prefabricated industrial materials. Cornaro et al. (2015) analysed the thermal performance of refugee tents retrofitted with aerogel pads as high-insulation material and showed a decrease in energy demand for heating by almost half, as well as improved indoor comfort conditions in summer without the need for mechanical cooling. The challenge here is the embodied energy and carbon in the production of high thermal insulation materials and their environmental impacts after the building's end of life. Lehne et al. (2016) highlighted that the issue of energy supply is an important concern and a crucial challenge to be solved within the humanitarian field.

Several studies have shown concrete examples for humanitarian housing projects that try to involve refugees in the housing design, or through giving them loans or technical support for construction (Aquilino, 2011b). Others have shown innovative housing ideas which demonstrate the power of design to improve lives through humanitarian architecture and movement towards socially conscious design (Kate and Sinclair, 2006). Only very limited work has been done in both combining integration and encouraging sustainable building practice in a participatory manner for refugee housing or emphasize on the performance of reconstruction projects and how it is directly and indirectly linked to the design and management of post-disaster multidisciplinary teams. (Johnson, Lizarralde, and Davidson 2006). While others like (El-Masri and Kellett 2001) took it from a holistic approach that mainly considered the complexity of other aspects with post-conflict rebuilding like socio-economic, cultural and organisational issues and how that is connected with shaping the built environment of refugee camps.

When it comes to algorithmic modelling methods, they have been continuously implemented in recent decades in the fields of architecture and urban planning. Algorithmic modelling has been used for humanitarian architecture, but the implementations were more to the side of shelter design rather than settlement design. Many of the existing advancements are parametric models of various shelters (Halin 2015; Yeung, Harkins 2010; Salvalai et al. 2015; Zanelli et al., 2013) or standardized camp models (Elie Daher, Kubicki 2017). In this study, we are trying to dig more into it and try to fill a knowledge gap in using parametric and algorithmic modelling on settlement level. This paper also attempts to gain an insight into the socio-cultural conditions of the communities prior to the disaster and into specific situations, which emerged after the destruction of vernacular towns and villages.

### 1.3 Case study description

The town of Balat (Figures 1 and 2) in the Western Desert of Egypt was chosen as a case study. The town represents a typical earthen vernacular settlement that used to be inhabited by 3000 dwellers (Dabaieh, 2011). Now only 20 % of its inhabitants are still living there. The rest left the town seeking modern buildings with better infrastructure and facilities (Dabaieh, 2012, 2013). After the town's natural wells dried out, it has been left with only a few water source outlets provided by the local municipality. The municipality also provides the town with the main infrastructure for electricity. That is considered a plus as for example, because the majority of vernacular settlements are off-grid or lack such infrastructure, electrical wiring is required. Mainly dry composting toilets used as no sewage or wastewater infrastructure exists in the town. The town is vulnerable to quick deterioration due to its lack of maintenance and neglect since the majority of its inhabitants abandoned it.

Figure 1. View of Balat town showing the earthen architecture and the compact vernacular urban fabric.


Figure 2. The central area of Balat.

The central area of Balat (Figure 2), comprised mostly of mud brick vernacular buildings, was chosen as the focus of this case study. Notably, the urban structure of this central part of the town does not follow a modernist grid distribution. This is an important feature for the assessment of a settlement as a potential refugee camp. There have been many critiques of the urban structure of the refugee camps stating that although the grid layouts are efficient for monitoring and control, they do not provide a feeling of home for displaced people (Williams, 2015). On the other hand, the urban spatial structure, like the one in Balat, with narrow alleyways and small community clusters may be more reminiscent of how people used to live in Syria, which is relevant in this refugee context since the country is still seen as home to those who fled. Small courtyards can foster neighborhood interaction and enhance the feeling of safety. In general, the notion of living in a camp is more repellent than the notion of living in a city. Even if vernacular settlements must be rebuilt or repurposed, they still maintain the skeleton of a city.

## 2. METHODOLOGY

The case study is based on the creation of the data model of a refugee camp. Later the data model is used to perform programmed data analyses and to give potential solutions to a defined set of problems. As opposed to traditional planning practice, here the task is divided between the planner and the algorithms which can lead to a better overall outcome.

### 2.1 Tools and methods

A graphical algorithm editor (Grasshopper for Rhino3D) is used alongside scripting to model desired algorithms. A particle-based relaxation engine (Piker, 2013) is used to model force fields. Each house is represented spatially by the centre point. An RTree is constructed from these points which are later used in proximity and clustering analyses.

### 2.2 Data collection

Prior to modelling, field investigations were conducted to explore the potential of using Balat as a case study. Field observations, field notes, semi-structured interviews and photo documentation were the tools used to collect data and facts about Balat town. Data on demography, building conditions, building use and existing infrastructure, was collected.

An archival search was also done to find updated maps of the town. The maps were updated using Arial photos, and through orthorectification, we managed to produce recent and close-to-accurate maps of Balat's current conditions.

### 2.3 Applied algorithms for settlement design and decision making

**2.3.1 Population distribution map:** As a starting point, map drawing of the case study area was available. The first task was to estimate the capacity of the settlement. First, residential buildings were identified. As a rule of thumb, approximately 30% of the plan area of those dwellings are dedicated to bedrooms. The UNHCR standards state that the minimum area per person should be 3.5 $m^2$. In cases where the cooking takes place inside the dwelling, which is our case, the area should be increased to be 4.5 $m^2$ (UNHCR, 2015b).

A hypothetical assignment of the number of floors was then made to resemble the vertical stratification of the settlement. Having more precise data at hand would have allowed the model to be recalibrated accordingly. Using the area, the hypothetical number of floors, the bedroom percentage area and minimum standard from UNHCR we computed the number of people that each of the dwellings could potentially fit (Figure 3).

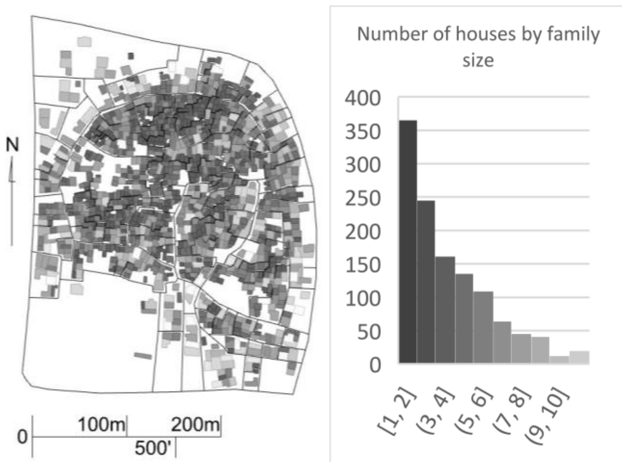


Figure 3. Weighted representation map and houses per family size histogram.

**2.3.2 Fire safety concerns:** UNHCR's fire safety standards require shelters to be separated by twice the length of the shelters' heights, or at least 2m apart. Considering that the settlements here are mostly built of mud, we can assume that fire propagation would be impeded. Nevertheless, to address the fire safety issue, a connectivity diagram was drawn to find clusters of continuously adjacent houses (Figure 4). As we can see, there are some clusters made up of over 50 attached houses (one cluster includes over 300 houses) which could pose concerns for fire safety. This analysis is aimed to aid CCCM professionals in addressing fire safety in the settlement.

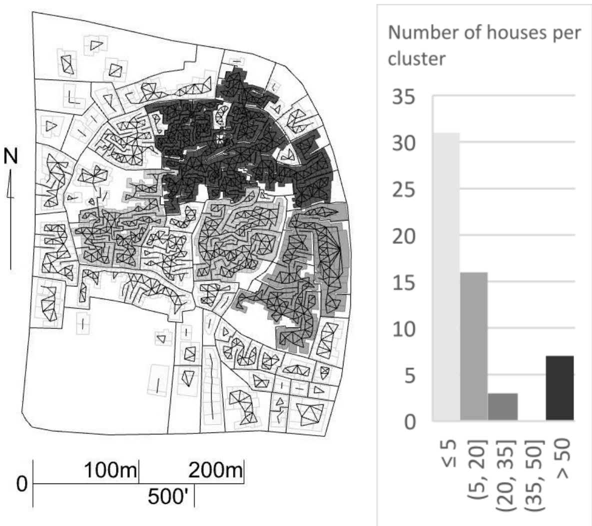


Figure 4. Connectivity graph of dwellings and cluster size histogram.

**2.3.3 Distribution of WASH facilities:** Water sanitation and hygiene (WASH) facilities are other issues that need consideration in refugee settlements. In our case study, the dwellings are equipped with composting dry toilets; however, there is no water distribution infrastructure capable of fulfilling the demand of water for showering and other household activities. In this regard, the site planners have the task of placing water distribution points that conform with the UNHCR requirement of maximum 200 m from all residences. In this case, the settlement has a higher density than a grid layout of a refugee camp. Also, the path leading to the water distribution point is more convoluted. So, the study has taken an even stricter standard of no more than 100 m. The objective is to find an optimal distribution of water supply tanks (or wells, if acceptable groundwater is available) and to estimate their capacity.

The initial assumption is that the distribution points should be placed on the roads so that they are accessible for water trucks to fill. Since some roads are too narrow for vehicles to pass through, minimum width of 3.7 m was used to determine whether each segment of the road network is suitable or not (Figure 5). For each segment of the road network, measurement points spaced 2 m apart, are distributed. From each measurement point, two rays are shot in both sides perpendicular to the road and tangent at the intersection point. The distances to obstacles are added to get the width of the road at that specific point (Figure 6). Afterwards, the segments that have at least one point with a measured width lower than the threshold are excluded meaning that a vehicle would be prohibited from passing through. The remaining pieces of the road network are tested on connectivity with the main circumscribing road. The disconnected pieces are also excluded leaving only the network that is accessible by a vehicle (Figure 7).

Figure 5. Measurement of existing road width.



Figure 6. Road width map (left).

Figure 7. Remaining road network (right).

As stated above, the general assumption is that the water distribution points should be located on the roads, more specifically on roads that are wide enough to accommodate water distribution vehicles. Thus, a series of potential points are distributed on the network with a spacing of 2.5m indicating all possible locations (Figure 8). The task is to choose a few of those that will jointly cover the entire settlement.

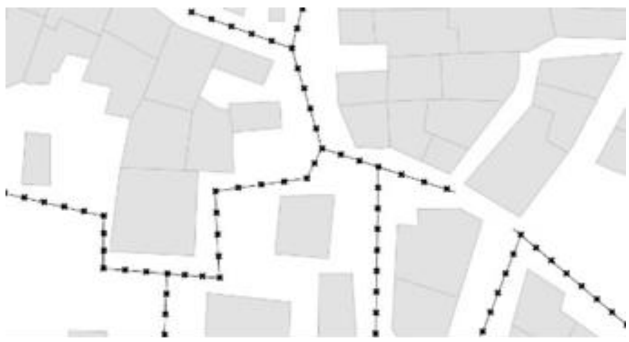

Figure 8. All potential distribution points.

Each of the dwellings is spatially represented by its center point with the weight calculated according to the number of people living there. From that collection of points, an RTree is created. Then, from each of the potential distribution points, proximity is calculated inside the RTree by locating all the dwellings that are within 100m of that specific point (Figure 9). The numbers of hypothetical inhabitants of those houses are then added to determine the number of people that each specific location can serve. From the collection of the distribution points weighted by their coverage, the one with the most coverage is selected.

Assuming that the first distribution point is found, we exclude the dwellings that are covered and also the potential distribution points that are close to the previously chosen one. The reason for exclusion is that their outreach zones would overlap with the chosen points. The remainder is a subset of house population that needs to be covered and a subset of distribution points that can be used. The same process is repeated until all of the houses are covered by water distribution points.

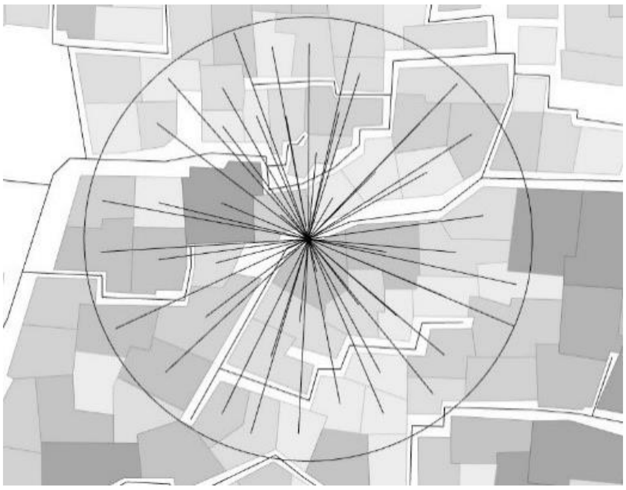

Figure 9. One distribution point outreach.

## 3. RESULTS AND DISCUSSION

### 3.1 Processing the resulting distribution point map

The first result is of the initial set of distribution points. This set is an optimal solution and ensures that all houses are covered (Figure 10). However, further refinement is done in order to take several additional considerations into account. The first consideration is that if the inhabitants of a certain dwelling are within reach of two distribution points, they will most likely choose the closest one. Based on this assumption, the graph is adjusted to connect each of the houses to the closest distribution point (Figure 11). It is also important to consider that within each distribution cluster; the points should be well-positioned to reflect people's needs within their cluster.

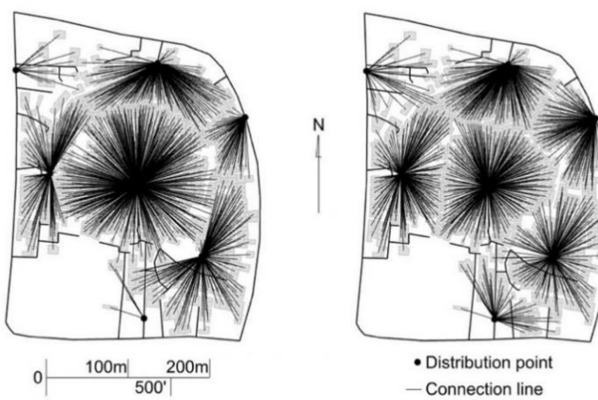


Figure 10. The initial distribution graph (left).

Figure 11. Proximity adjusted distribution graph (right).

The assumption here is that each house's inhabitants will tend to 'pull' the distribution point closer to them. In order to model this, each connection line is modelled as a spring with the stiffness value substituted with the number of inhabitants living at that house. Using Hook's law, the forces were calculated based on inhabitants' weight and initial distance. The further the house is from the distribution point, and the more people it hosts, the greater the pulling force will be. The described force model was implemented in a Kangaroo physics simulation engine. Thus, we were able to simulate 'spring relaxation[1]' which resulted in the updated positions of distribution points (Figure 12). Since some of the repositioned distribution points may no longer be on the road network, they are repositioned to the closest point on the road network, giving the final distribution of water supply points (Figure 13). The resulting walking distances to the allocated distribution points are calculated and plotted in a histogram (Figure 14). As we can see, the distribution is optimal, with no houses further than the designated 100 m.

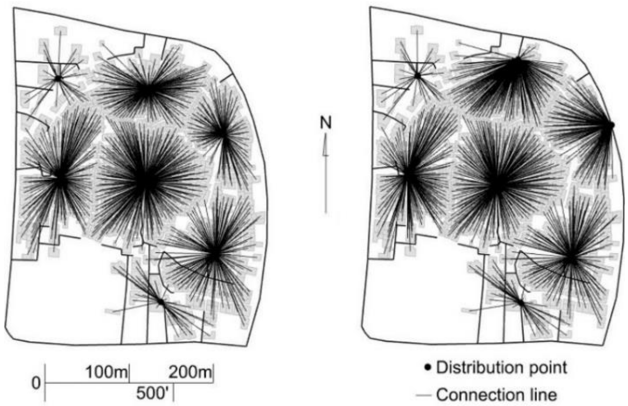


Figure 12. Weighted force adjusted distribution graph (left).

Figure 13. Repositioned distribution graph (right).

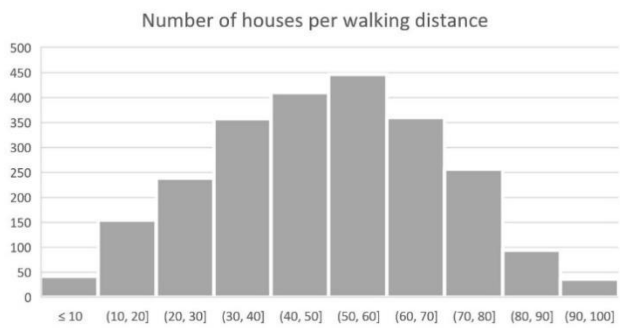


Figure 14. Houses per walking distance histogram.

### 3.2 Alternative approaches

Computational modelling gives possibilities for many different approaches to the defined problem. This study case is one such approach. It is worth mentioning that similar problems are tackled in the field of operations research, and some mathematical disciplines such as linear programming can be adopted for decision making. The Simplex algorithm is one example of such an optimization technique. Unfortunately, so far, linear programming algorithms are not yet widely implemented

[1] In spring relaxation all the given lines are treated as springs to estimate the internal force F=kx. Where k is the spring stiffness (represented by the amount of people in our case) and x shows the difference between the actual length of the line and the goal length. In our case the goal length is 0.

in the existing graphical algorithm editing tools. Aside from this, the implemented tools include several genetic optimization and machine learning algorithms that can be tailored to deal with specific problems in humanitarian architecture.

## 4. CONCLUSION

The aim of this case study was to develop a methodology for supporting refugee camp site planning and decision-making processes through bespoke algorithms and computational models. The algorithms developed were able to yield data-rich analyses of inhabitation density, fire safety and road access of the examined vernacular settlement with an intricate spatial structure. The algorithms also helped locate the optimal placement of water distribution points. This study shows that the implementation of such techniques can result in creating better refugee settlements in terms of basic infrastructure and housing quality.

The proposal hopefully offers a solution for establishing a peaceful and safe society through reusing existing vernacular settlements that have the potential to reduce social inequalities by offering decent shelters and equal access to services. In addition, rehabilitating existing vernacular settlements can provide privacy, protection and better living conditions, which are critical requirements for refugees to start a recovery and reconstruction programme after a crisis. Hosting refugees in a community-like built environment will also help reduce the trauma effect and will speed up healing and recovery when they feel like being in a home rather than a tent.

## ACKNOWLEDGEMENTS

The activities presented in this paper are aided by Politecnico di Milano research grant and equipment and tools provided by the Centre of Information Technologies and Architecture at KADK. We would like to also thank urban data scientist Gevorg Yeghikyan from Scuola Normale Superiore in Pisa for his valuable contributions and discussions about the creation of a data model of an urban structure and optimization methods.

## REFERENCES

Dabaieh, M., 2013. “Participatory Action Research as a Tool in Solving Desert Vernacular Architecture Problems in the Western Desert of Egypt.” *Action Research*. https://doi.org/10.1177/1476750313484504.

Dabaieh, M., 2015. *More than Vernacular : Vernacular Architecture between Past Tradition and Future Vision*. Lund: Media-Tryck.

Dabaieh, M., Makhlouf, N., Hosny, O., 2016. “Roof Top PV Retrofitting: A Rehabilitation Assessment towards Nearly Zero Energy Buildings in Remote off-Grid Vernacular Settlements in Egypt.” *Solar Energy*. https://doi.org/10.1016/j.solener.2015.11.005.

Daher, E., Kubicki, S., Halin, G., 2015. “Parametric Process for Shelters and Refugees’ Camps Design.” *Proceedings of the 33rd International ECAADe* 2 (September): 541–48.

Daher, E., Kubicki, S., 2017. “Technologies in the Planning of Refugees’ Camps: A Parametric Participative Framework for Spatial Camp Planning.” *IHTC 2017 - IEEE Canada International Humanitarian Technology Conference 2017*, 207–12. https://doi.org/10.1109/IHTC.2017.8058189.

El-Masri, S., Kellett, P., 2001. “Post-War Reconstruction. Participatory Approaches to Rebuilding the Damaged Villages of Lebanon: A Case Study of Al-Burjain.” *Habitat International*. https://doi.org/10.1016/S0197-3975(01)00023-6.

Feilden, B. M., 2003. *Conservation of Historic Buildings*. Oxford: Architectural Press.

Johnson, C., 2007. “Strategic Planning for Post-Disaster Temporary Housing.” *Disasters*. https://doi.org/10.1111/j.1467-7717.2007.01018.x.

Johnson, C., Lizarralde, G., and Davidson, C. H., 2006. “A Systems View of Temporary Housing Projects in Post-Disaster Reconstruction.” *Construction Management and Economics*. https://doi.org/10.1080/01446190600567977.

Misra, M., 2009. “Conservation of Ruins.” *International Journal of Environmenta Studies*.https://doi.org/10.1080/00207230802586705

Murphy, M. P., Ricks, A., 2013. “Beyond Shelter: Architecture and Human Dignity.” *The Journal of Architecture*. https://doi.org/10.1080/13602365.2013.767054.

Piker, D., 2013. “Kangaroo: Form Finding with Computational Physics.” *Architectural Design* 83 (2): 136–37. https://doi.org/10.1002/ad.1569.

Salvalai, G., Imperadori, M., Scaccabarozzi, D., Pusceddu, C., 2015. “Thermal Performance Measurement and Application of a Multilayer Insulator for Emergency Architecture.” *Applied Thermal Engineering*. https://doi.org/10.1016/j.applthermaleng.2015.02.062.

El-Masri, S., Kellett, P., 2001. Post-war reconstruction. Participatory approaches to rebuilding the damaged villages of Lebanon: A case study of al-Burjain. Habitat Int. doi:10.1016/S0197-3975(01)00023-6

UNHCR, 2014. UNHCR Policy on Alternatives to Camps. https://www.refworld.org/docid/5423ded84.html.

UNHCR, 2015a. “Regional Refugee & Resilience Plan 2016-2017 in Response to the Syria Crisis.” *Regional Strategic Overview*. https://doi.org/10.1177/009365027900600102.

UNHCR, 2015b. *UNHCR Handbook for Emergencies*. *Unhcr*.

UNHCR, 2018. “Global Trends: Forced Displacement in 2017.” *Global Trends*, no. 25 JUNE 2018: 76.

UNHCR, 2020. “Regional Strategic Overview 2020-2021. Regional Refugee & Resilience Plan (3RP). In Response to Syrian Crisis.”

UNISDR, 2008. “Indigenous Knowledge for Disaster Risk Reduction.” *Indigenous Knowledge for Disaster Risk Reduction*. https://doi.org/10.1007/s00267-010-9471-9.

Yeung, W., Harkins, J., 2010. “Digital Archi for Humanitarian Design: A Case Study of Applying Digital Technologies in Post-Disaster Reconstruction.” *New Frontiers - Proceedings of the 15th International Conference on Computer-Aided Architectural Design in Asia, CAADRIA 2010*, 413–22.

Zanelli, A., Monticelli, C., Viscuso, S., Mazzola, C., 2013. “Parametric Design and the Manufacturing Process of an Ultra-Lightweight Roof System for Humanitarian Relief Contexts.”