Generating Urban Connectivity Systemic Interventions

Bio-corridors and Their Prototypes

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Abstract

This paper focuses on how to generate urban bio-corridors within the framework of the Synergetic Landscapes Project. The project is set up to deal with the problematique of the relationship between human and urban wildlife in Grangetown, Cardiff, Wales, UK. The paper discusses the research on the context of the bio-corridor on a more general level. Based on this, the urban proposal for Grangetown is pointed out, and potential bio-corridors in Grangetown are suggested. Lastly, the paper proposes a prototype called Possible Fabrication as one of more possible leverage points for the urban proposal. Gigamapping is used as a tool for the whole design and research process.

1. Introduction

1.1 Background of the increasing amount of wildlife in cities

In recent years, wildlife increases in urban environment with the expansion of urbanization. Urban environment seems to be increasingly conducive to wildlife all around the world. Most of the species can get food, or enjoy a higher survival rate (Barkham, 2017). However, at the same time, many of the species face many hidden dangers such as habitat loss, reduction in native biodiversity, greater disturbance from human, and problems aligned to pollution and ecosystem degradation (Seto, Güneralp, & Hutyra, 2012). As for human, the increasing number of wildlife might offer a possibility for people to get close to nature. People will enjoy more positive emotions when they stay in a green space which is wildlife rich (Cameron et al., 2020). However, it is undeniable that the urban wildlife will also have a negative impact on human daily life such as health issues (e.g. parasitic infection) (Paul, 2014). The conflict and integration between human and non-human citizens in cities are becoming a largely discussed topic (Figure 1).

1.2 Introduction of Synergetic Landscapes Project

Synergetic Landscapes Project is set up to deal with the problematique of the relationship between human and urban species. There were seven members in the project team including the project leader, the second author. Each member except the project leader focused on one of the research areas, namely, bio-corridor, blockchain, circular economy, materials, stakeholder and community, and collective giga-map. All those research areas shared strong connection with each other. Based on the six research branches, six members generate six prototypes to create a synergetic landscapes system covering the six research areas. The paper discusses the research branch of Bio-corridor and present the design process of the prototype called possible fabrication (Figure 2Figure 2).

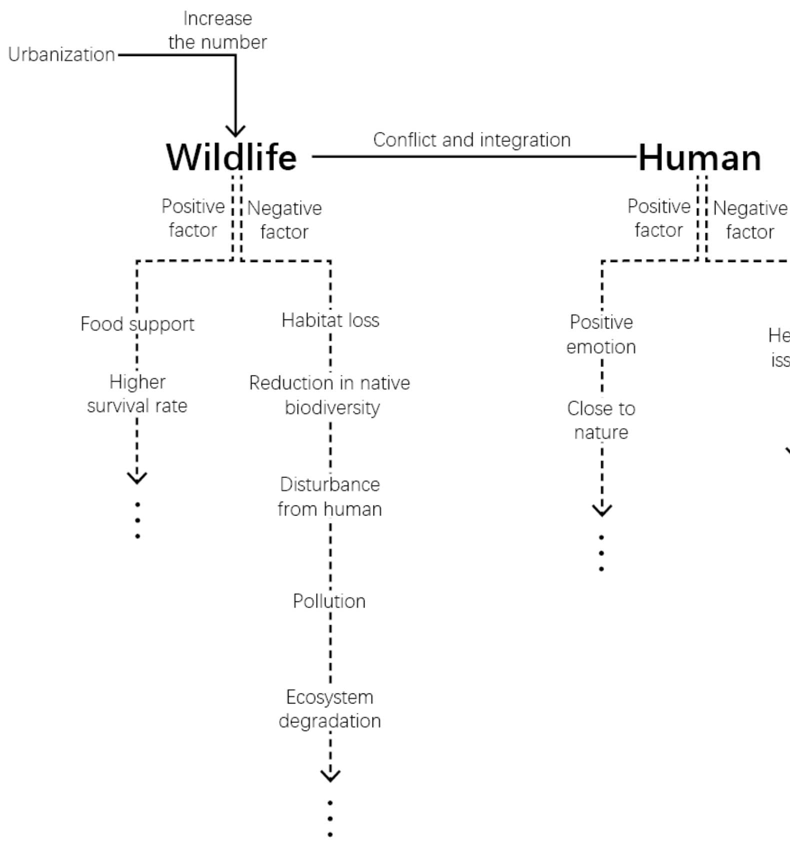


Figure 1 Background of Urban Wildlife (Wang, 2020)

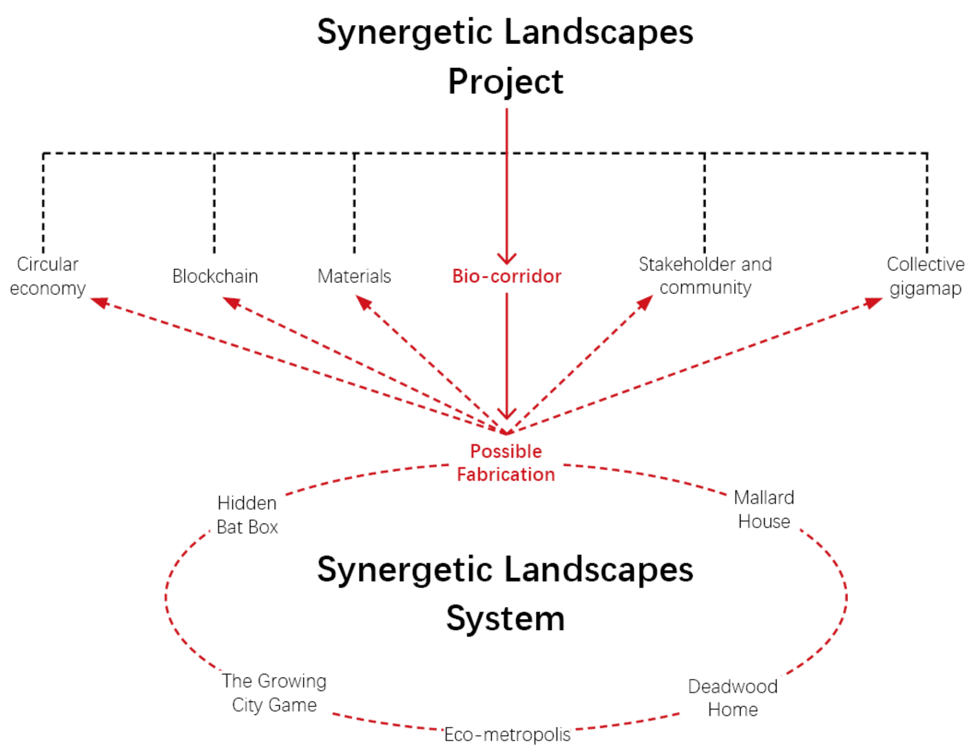


Figure 2 Synergetic Landscapes Project Overview (Wang, 2020)

2. Methodology

2.1 Application of gigamap as the medium connecting research process and physical interventions

Research process was to figure out the current situation and the feedback of the interventions while physical intervention is the tool to deal with the problematique from the research. Gigamapping was the medium between design and research, synergising the overall team (Figure 3).

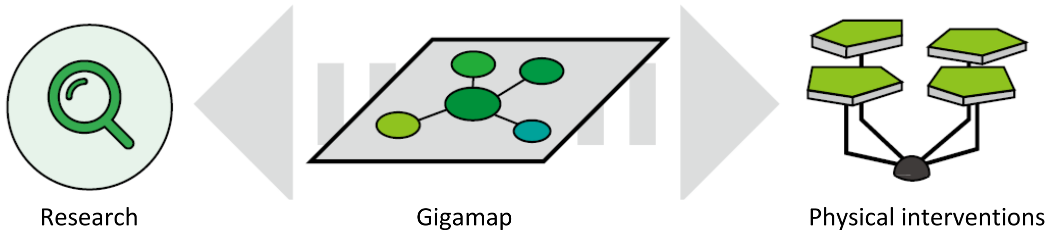


Figure 3 Application of GIGA-map (Wang, 2020)

2.2 Synergetic Landscapes Codesign System

Synergetic Landscapes Project consists of six research branches, which shared strong connection. The first author was responsible for the research on bio-corridor. Therefore, this paper focuses on this area. It also discusses the generation of a prototype based on this field. Moreover, the paper presents the biological system of the six prototypes which are designed from different team members (Figure 4).

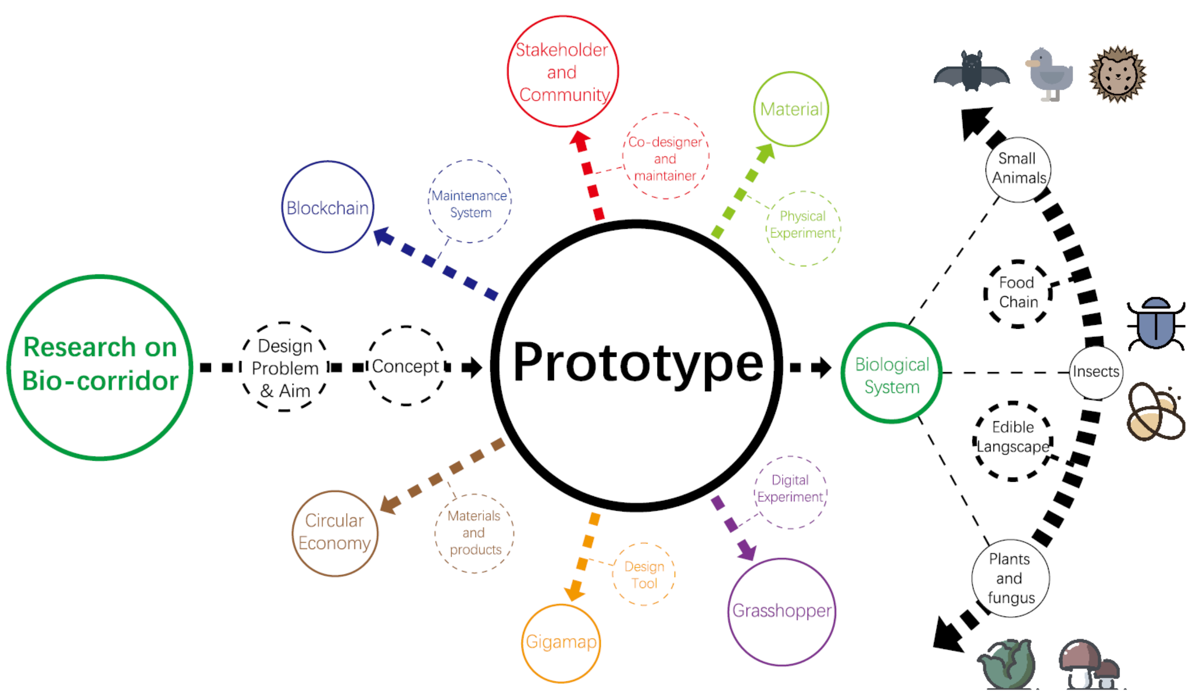


Figure 4 Synergetic Landscapes Codesign System (Wang, 2020)

3. Research on bio-corridors

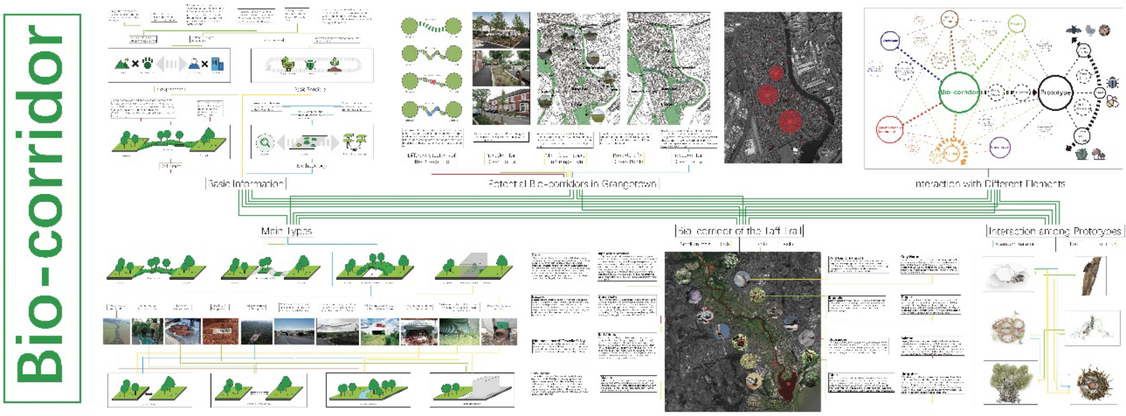


Figure 5 GIGA-map of Bio-corridor (Wang, 2020)

3.1 The Location

The research on bio-corridors focuses on the residential area in Grangetown, Cardiff (Figure 6). Other research areas are also conducted in the same district. The selected district is an old block with high-density housing. The research tries to activate the harmonious relationship between human beings and wildlife by investigating and diagnosing the background of the district, the human behaviour, the distribution of the green space and the biodiversity of different micro-habitats.

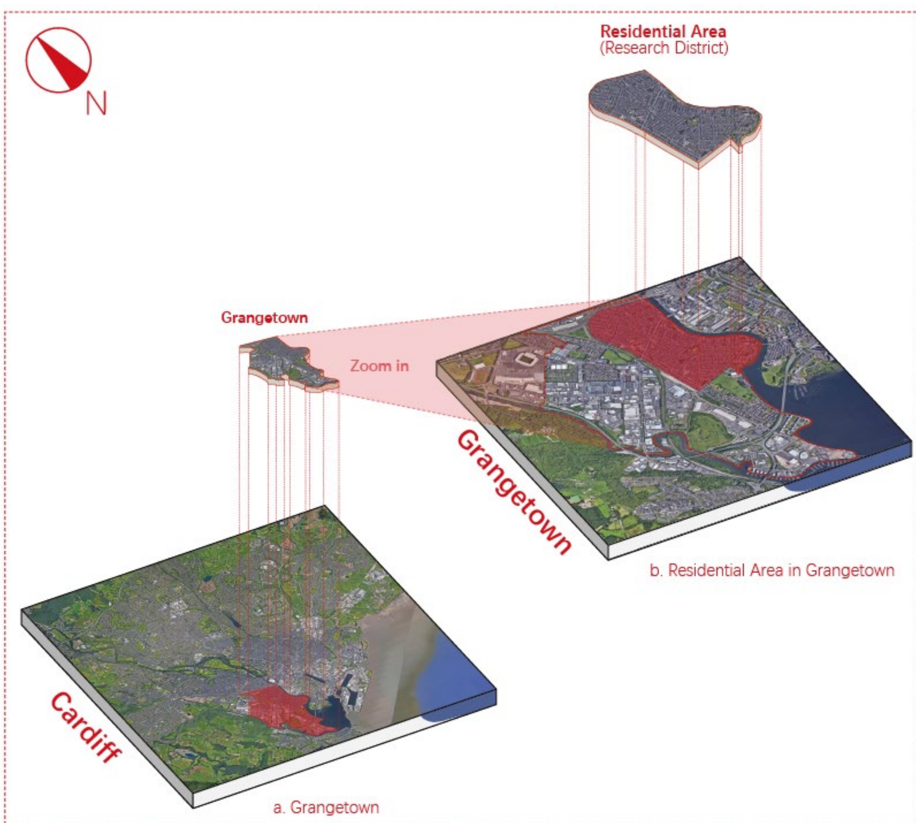


Figure 6 Research District Selection (Wang, 2020)

Grangetown is located in the south of Cardiff (Figure 7-a), capital of Wales, which is one of the five towns in the city. It is bordered by Riverside, Canton and Butetown and it is faced with a large area of greenland outside the city in the southwest (Figure 7-a). River Taff and River Ely wind their ways on the west and east sides of the town and meet in the Cardiff Bay (Figure 7-b). Along River Taff, there is a liner green space called Taff Trail which passes though Grangetown and ends at Cardiff Bay (Figure 7-c). Benefit from it, Grangetown is rich in biodiversity. Adjacent to Cardiff Bay, Grangetown is profiting greatly from the development nearby and the living conditions and the basic infrastructure of the area are experiencing a high-speed improvement (Figure 7-d).

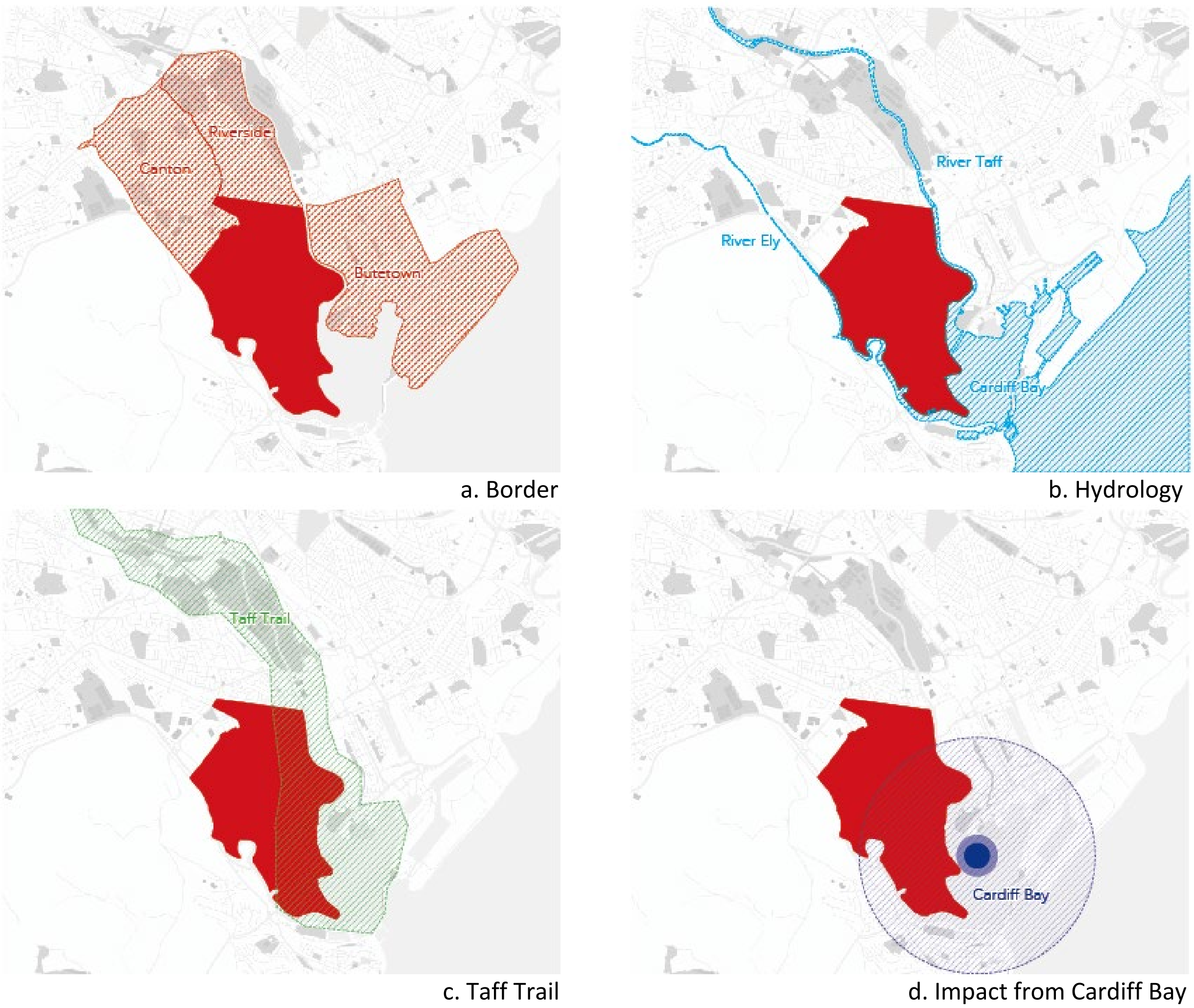
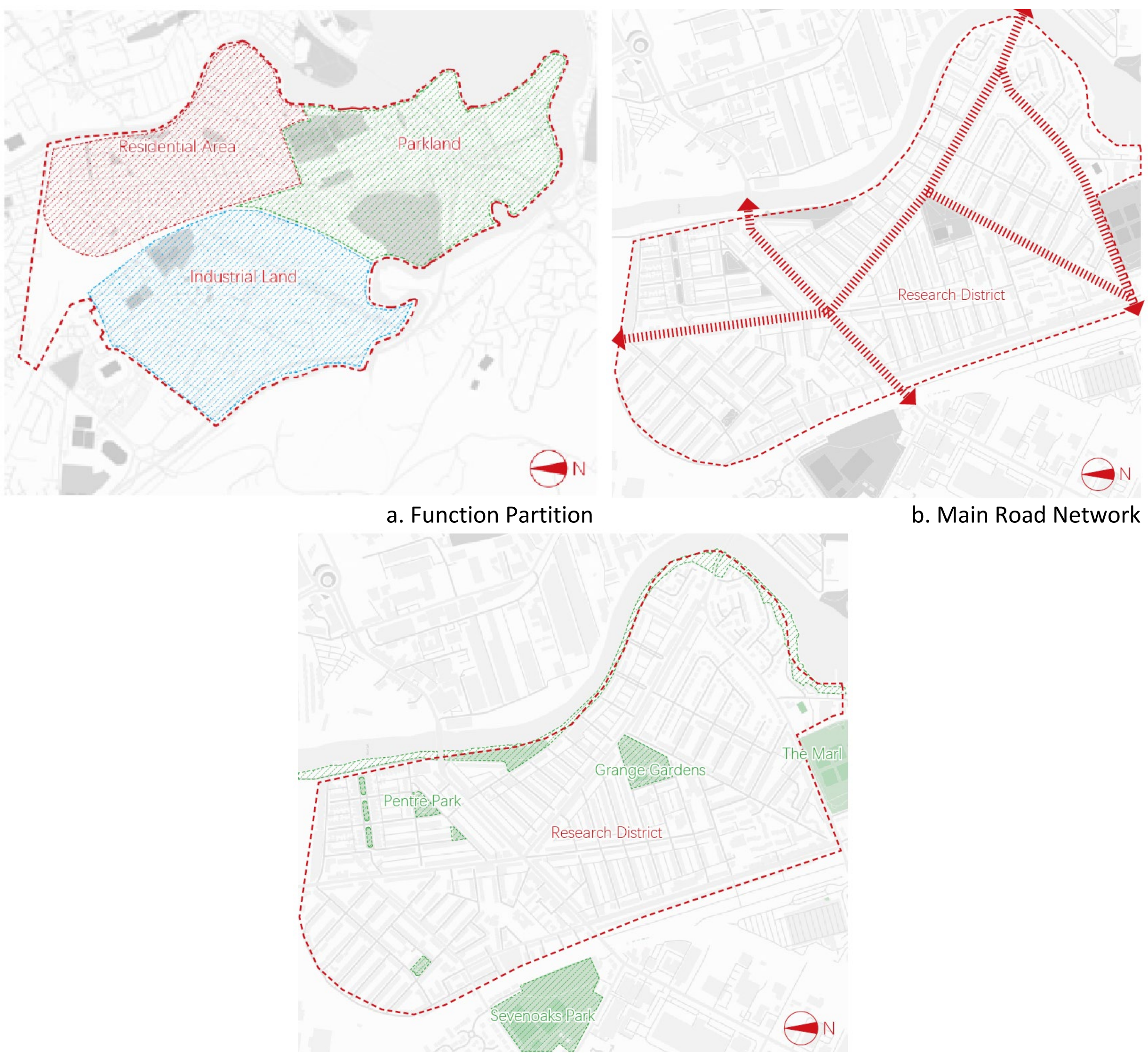


Figure 7 Context of Grangetown (Wang, 2020)

Grangetown could roughly be divided into three parts by function. The research district is located in the northeast of Grangetown which is mainly a residential area. Most of the factories are built in the West and parks in the south (Figure 8-a). Except for a few main roads that run through the whole block, there are many paths growing in the whole area (Figure 8-b). Grangetown is a diverse and multiracial district and has a significant population of Somali, Asian and mixed-race residents (Wightwick, 2019), so there are a lot of religious buildings in Grangetown like Swaminarayan Temple (Figure 9). As a typical old residential area, there is few large-scale green spaces (Figure 8-c). There are three main parks within the area, namely, Pentre Gardens, Grange Gardens and Hereford Street Park and Grange Gardens is the largest one in the centre. The largest community centre, Grange Pavilion, is also built in it. Grange Gardens plays the role as the centre for outdoor activities of local residents.



a. Function Partition

b. Main Road Network

c. Main Green Space

Figure 8 Context of the Research District (Wang, 2020)

Figure 9 Main Building and Parks (Wang, 2020)

3.2 Diagnosis of green space in research district

There are three different kinds of green space which is of different scale in the research district, namely, small parks, house backyards and street trees (Figure 10). As one of the most basic greening forms, street trees are widely distributed in the area, but this form of greening is small and scattered. It is hard for animals to stay or live except insects and birds. House backyards might be a little bigger than the street trees. As part of living space of residents, a backyard might become a place where human and urban wildlife communicate with each other. However, the size of the backyard is always limited, and different backyards are bordered by fences. As for small parks, it would be the best place for different species to nest, migrate and interact. Within the research district, there are three main parks, which is Grange Gardens, Hereford Street Park and Pentre Gardens (Figure 10). Grange Gardens is the largest one of the three and play the role as the community in the neighbourhood (Figure 11). There are some wildlife showing up in the park even if the number of them is small. The park already has a certain amount of biodiversity. Nevertheless, it has not been enough to be called as a habitat or a micro-habitat.

Figure 10 Green Space Distribution (Wang, 2020)

Figure 11 Aerial View of Grange Garden (Edited from photo by Google Earth 2020)

On the whole, the green space of the research district is not enough and scattered. Limitation of area and connectivity will result in the reduction of biodiversity (Kruess & Tscharntke, 1994). At the same time, the migration for wildlife would be a problem. If urban animals want to travel from one biotope to another, they might need to cross the street and be exposed to the public. By diagnosing the green space, a conclusion could be drawn that Grangetown might be faced with problems which are caused by the negative properties of the main green space (Figure 12).

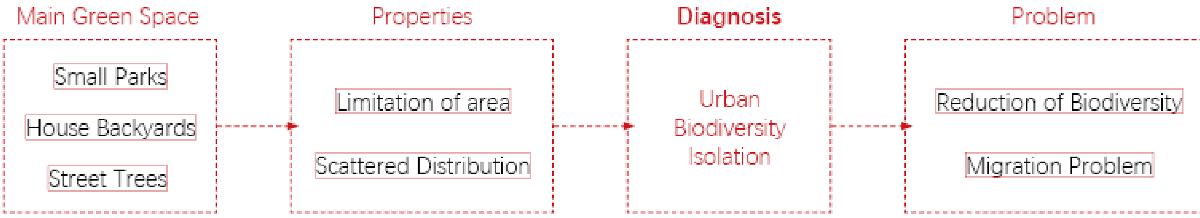


Figure 12 Diagnosis of Green Space (Wang, 2020)

3.3 General proposal

3.3.1 Background of the urban biodiversity isolation

The extra-somatic adaptations, technological dominance, and success of mankind in colonizing every terrestrial habitat have no parallel (Hill, Barton, & Magdalena Hurtado, 2009). With the evolution of human, the influence on Earth is more and more tremendous. Cities can be regarded as one of the largest products of human areas. The living space of human becomes huge and continuous while homes of other species have become fragmented. Within the city, the connectivity among different green space may be blocked by roads, buildings or other artifacts. On a larger scale, several habitats may be isolated by cities.

In fact, there are still many species living in the city for now including animals, plants and others, but the isolation puts species in danger. The interdiction of biological information exchange will lead to the decline of biodiversity among species or induce diseases (Kruess & Tscharntke, 1994). Only a few creatures which have better migration capacity like birds or rely less on trans-regional species exchange like plants may survive such a fate. It is very difficult for flightless terrestrial animals to migrate in cities. If this problem is not taken seriously, the wild animals in the city may disappear in the future.

In conclusion, the living conditions of human and wildlife change in opposite trends with the acceleration of the urbanization process. Normally, an undeveloped land with pure natural environment is conducive to the survival of wildlife (Figure 13-Stage A). This does not mean that all wildlife has the best living conditions under this circumstance, but the overall biodiversity of the habitat is particularly rich. With the advent of human, scattered human settlements appear in the wild (Figure 13-Stage B). Human beings are still vulnerable groups comparing with wild beasts. After the formation of the city, mankind has become the ruler of the urban environment (Figure 13-Stage C). Only small animals could survive in the small green belts of the city. As a result, biodiversity isolation phenomenon appears, and leads to a series of problems.

3.3.2 The proposal of generating biological corridor in the city

The isolation might be alleviated by corridors between different biotopes. This kind of corridor is called biological corridor which could be abbreviated to bio-corridor. It is a geographically defined area which provides connectivity between landscapes, ecosystems and habitats, natural or modified, and ensures the maintenance of biodiversity and ecological and evolutionary processes (CCAD, 2002).

In general, the bio-corridor is a corridor for wildlife to live and migrate among different fragmented biotopes. Also, through the movement of animals, seeds of plants are spread. If it is possible to create bio-corridors in the city, Stage C could be transferred to Stage D with the naturalization measures (Figure 13-Stage D). Wildlife could migrate through bio-corridors on a small scale. The living conditions of wild animals will be significantly improved. At the same time, the process might also have a positive impact on human community. People could benefit from increased greening and biodiversity (Cameron et al., 2020). Urban biological environment and biodiversity information should be studied to figure out the feasible way to create urban bio-corridors in Grangetown.

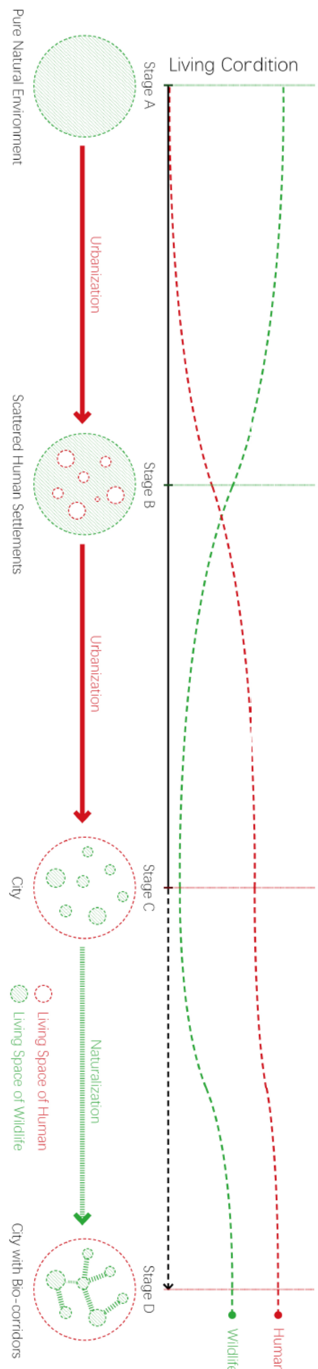


Figure 13 Urbanization Process and Naturalization Proposal (Wang, 2020)

3.4 Knowledge mapping

In order to study how to create urban bio-corridors, four research keywords are selected, namely bio-corridor, wildlife, people, materials (Figure 14). Generating urban bio-corridor is the main aim of the research, so the information of it is essential in the knowledge mapping. As one of unity of opposites in the city, people and wildlife should be taken seriously in the research process which are also selected as the two of the four corners. As for materials, they are the medium of other keywords and offer the possibility to conduct the practical research. The final design of the urban bio-corridor will be achieved by prototypes, so it should be placed in the centre of the knowledge mapping. Through pairwise combination of primary keywords, secondary keywords are derived. Through the brainstorm, the third level keywords are generated based on the primary and secondary level keywords. This map will serve as a blueprint for the first literature review.

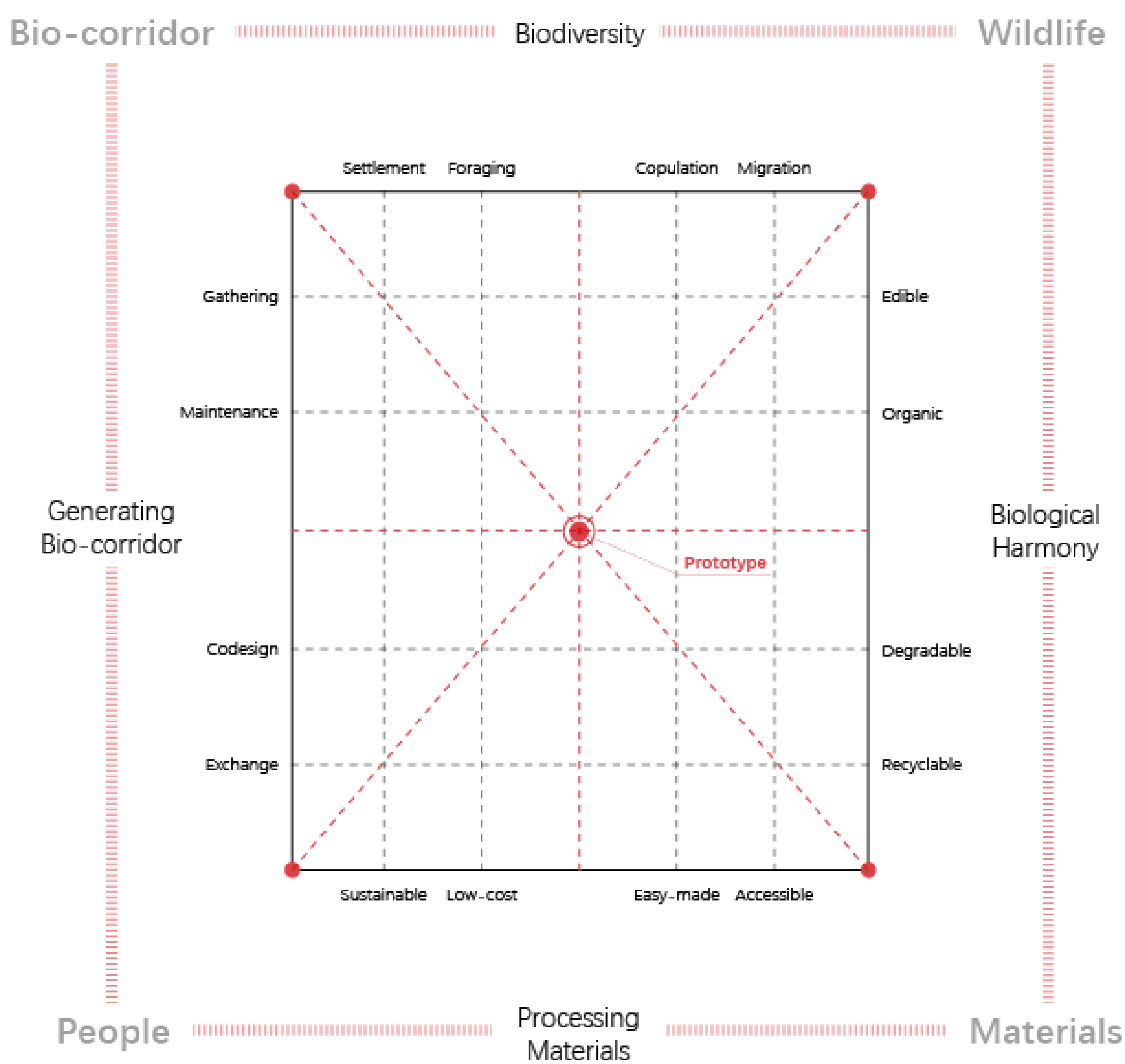


Figure 14 Knowledge Mapping (Wang, 2020)

3.5 First literature review

In the first literature review, nine representative papers are selected from papers which is related to bio-corridor, wildlife, people and materials. The information networks of the nine papers are mapped according to the knowledge Map in 3.4. The keywords mentioned in the papers but not discussed in depth will not be covered (Figure 15).

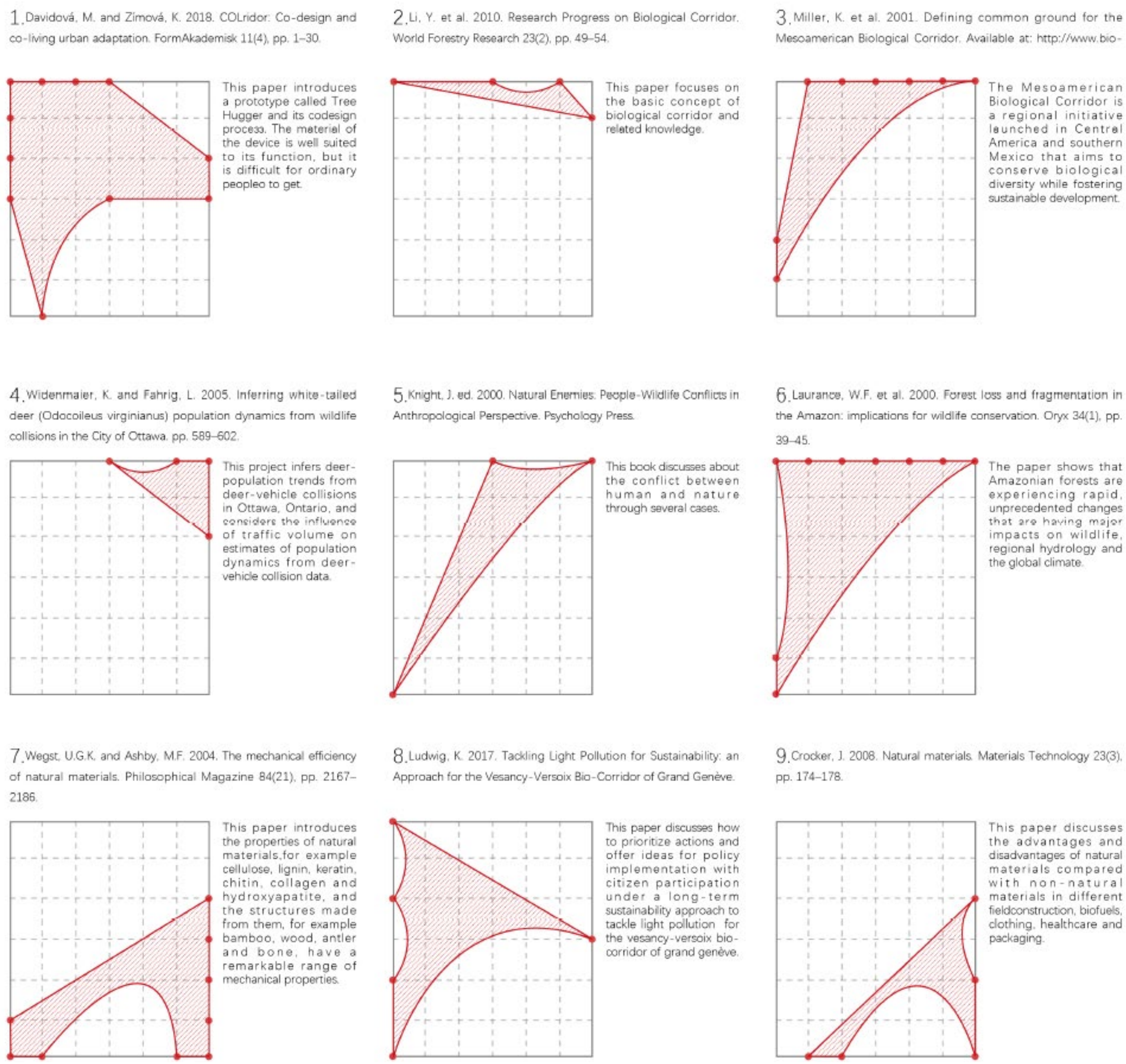


Figure 15 First Literature Review (Wang, 2020)

3.6 Research question and aim

3.6.1 Research concept

The term, "bio-corridor", comes from the natural ecosystem. It is used for the discussion of the wildlife migration in the wild. Nowadays the migration of wildlife is becoming increasingly important to solve the biodiversity isolation in the city. Many scholars have carried out the investigation on the bio-corridors, but there are few papers focus on the urban bio-corridors. As a result, it is of great value to extend "bio-corridors" to the urban ecosystem (Figure 16).

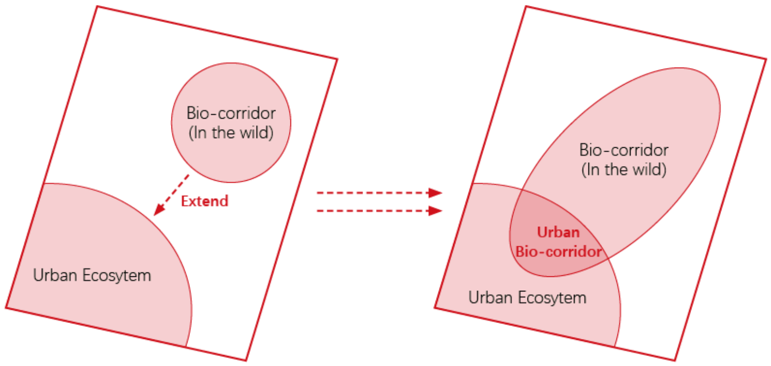


Figure 16 Research Concept (Wang, 2020)

3.6.2 Research gap

By overlapping all the information networks of the first literature review, a general research gap could be defined (Figure 17). After zooming into the research gap and analysing it with the related keywords comprehensively, it could be seen that there is not much paper focusing on generating bio-corridor through codesign process with local people by using low-cost, easy-made and accessible materials.

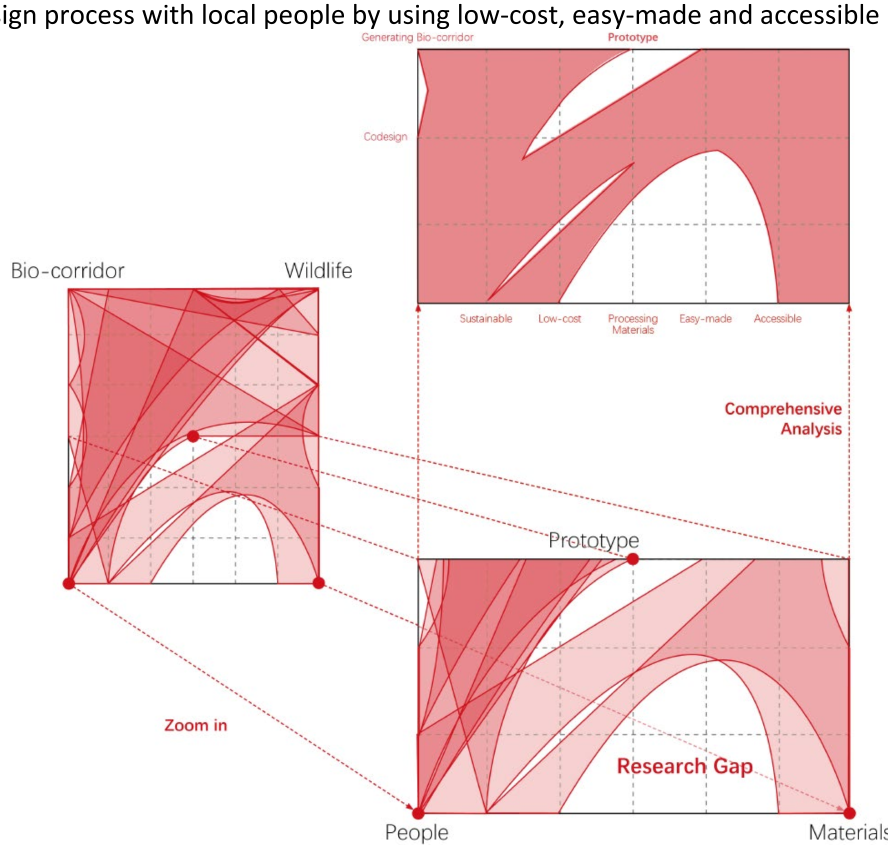


Figure 17 Research Gap (Wang, 2020)

3.6.3 Research question and strategy

Based on General Proposal (3.3), Research Concept (3.6.1) and Research Gap (3.6.2), the research question could be defined as how to generate urban bio-corridors taking Grangetown as an example (Figure 18). In urban level, the authors try to find a solution to map the potential bio-corridors in Grangetown which could adapt to the ecological characteristics of the city. In architecture level, generating prototype is the essential way to make the urban solution come true. In order to answer the research gap, the prototype is designed through codesign process and suggested through DIY proposal to the community. In the actual construction process, more natural materials are be used which are low-cost, easy-made and accessible.

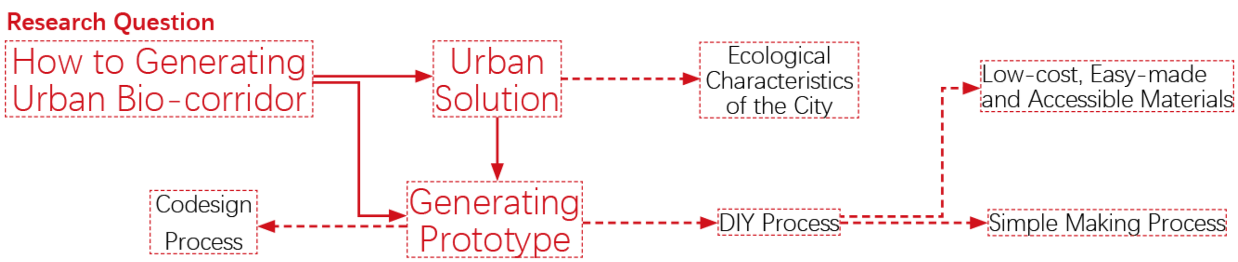


Figure 18 Research Question and Strategy (Wang, 2020)

3.7 Second literature review

According to the research question (3.6.3), second literature review focuses on the information related to the bio-corridor. Different aspects of the bio-corridor are summarized in Figure 19. This review plays a guiding role in the following urban strategies and prototype design.

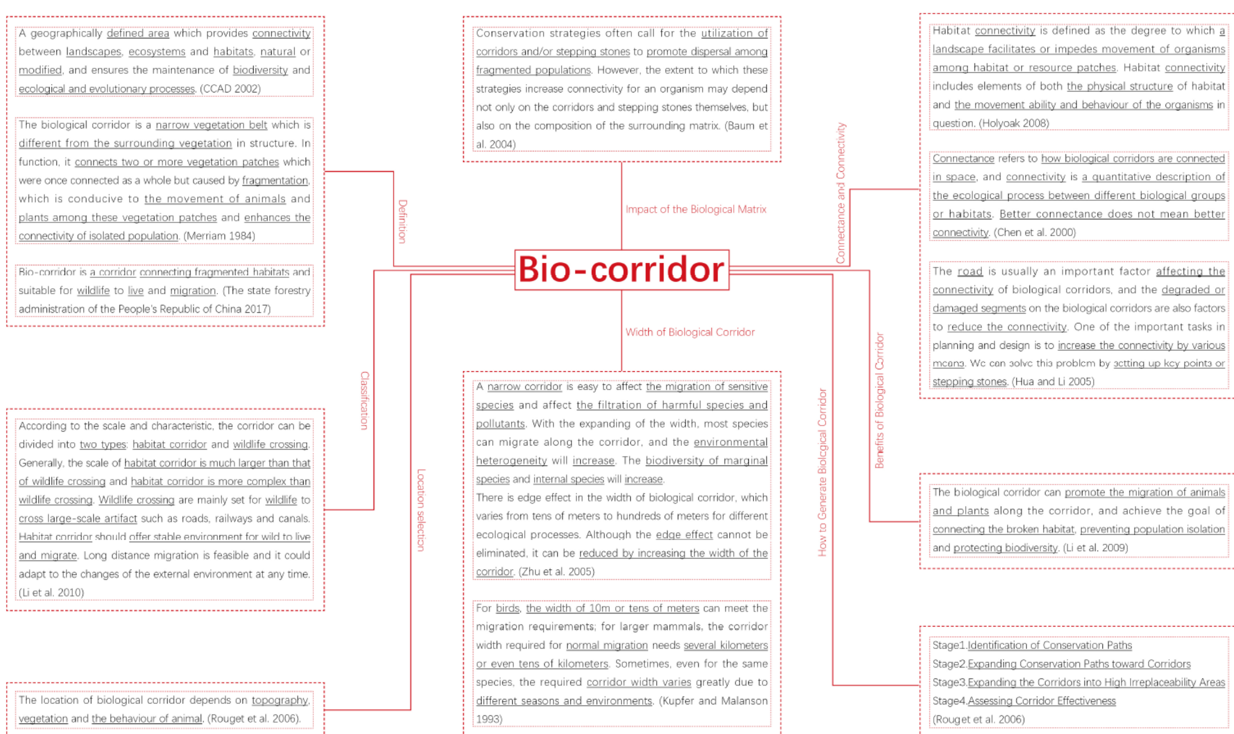


Figure 19 Second Literature Review (Wang, 2020)

3.8 Analysis of different forms of bio-corridors

Bio-corridors are more common in the wild. In order to meet the different needs of the biota and adapt to the different geographical environment, bio-corridors have evolved in different forms. According to the scale and characteristic, bio-corridors could be divided into two main forms: habitat corridor and wildlife crossing. Generally, the scale of habitat corridor is much larger than that of wildlife crossing. Habitat corridor should offer a stable environment for wild to live. Long-distance migration is feasible, and it could adapt to the changes in the external environment at any time (Li et al., 2010). Wildlife crossing is mainly set for wildlife to cross large-scale artifact such as roads, railways and canals.

In terms of the habitat corridor, the most common form in the wild is the linear bio-corridor (Figure 20-a). The formation of linear bio-corridor and the migration of wildlife are promoting each other mutually. When wildlife migrates between different biotopes, they are not just cross what between the biotopes. They tend to move along the route whose environment could offer basic conditions for survival. After numerous explorations, a relatively fixed migration route will be formed which is so-called linear bio-corridor. With countless migrations along the corridor, seeds of plants are spread and the biodiversity in the region will be further improved. The environment of corridor will be further optimized due to the migration of different populations.

Regarding wildlife crossing, there are two common forms: Bridge bio-corridor and Tunnel bio-corridor (Figure 20-b). Most of them are man-made to solve artificial barriers. Bridge bio-corridor is created for wildlife to cross over hindrance of low height such as freeways and railways. And for the high obstacles, it is hard to move over it, so it is better to construct tunnel bio-corridor to get through. Tunnel bio-corridors offer a possibility for species to cross obstacles directly such as small mountains.

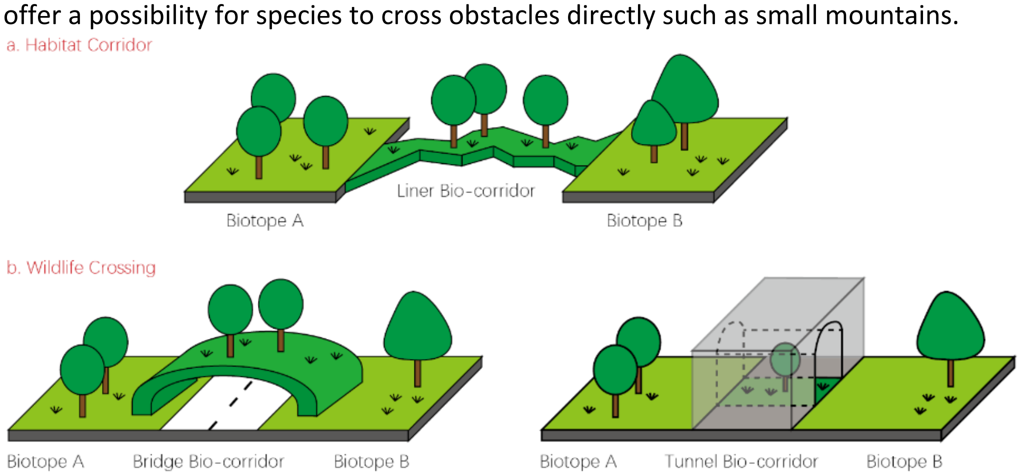


Figure 20 Main Forms of Bio-corridors (Wang, 2020)

3.9 The proposal of punctate bio-corridor

In this section, several precedents are matched to different forms and situations of bio-corridors. After analysis and comparison, a conclusion is drawn that different forms of bio-corridors are applicable to different situations. According to the classification of bio-corridors (3.7) and the main forms of bio-corridors (3.8), there is no appropriate bio-corridor form that could be matched to some of the precedents (Figure 21-b, Figure 21-c, Figure 21-d). The three precedents share a same property that they try to generate bio-corridor by placing several installations and connecting them. It is difficult to organize continuous liner bio-corridor in the city, so connecting small green spots to be a punctate bio-corridor could the best way to solve the biological migration problem in cities. Some prototypes have been designed in this way, but there is no paper elaborating on the punctate bio-corridor systematically.

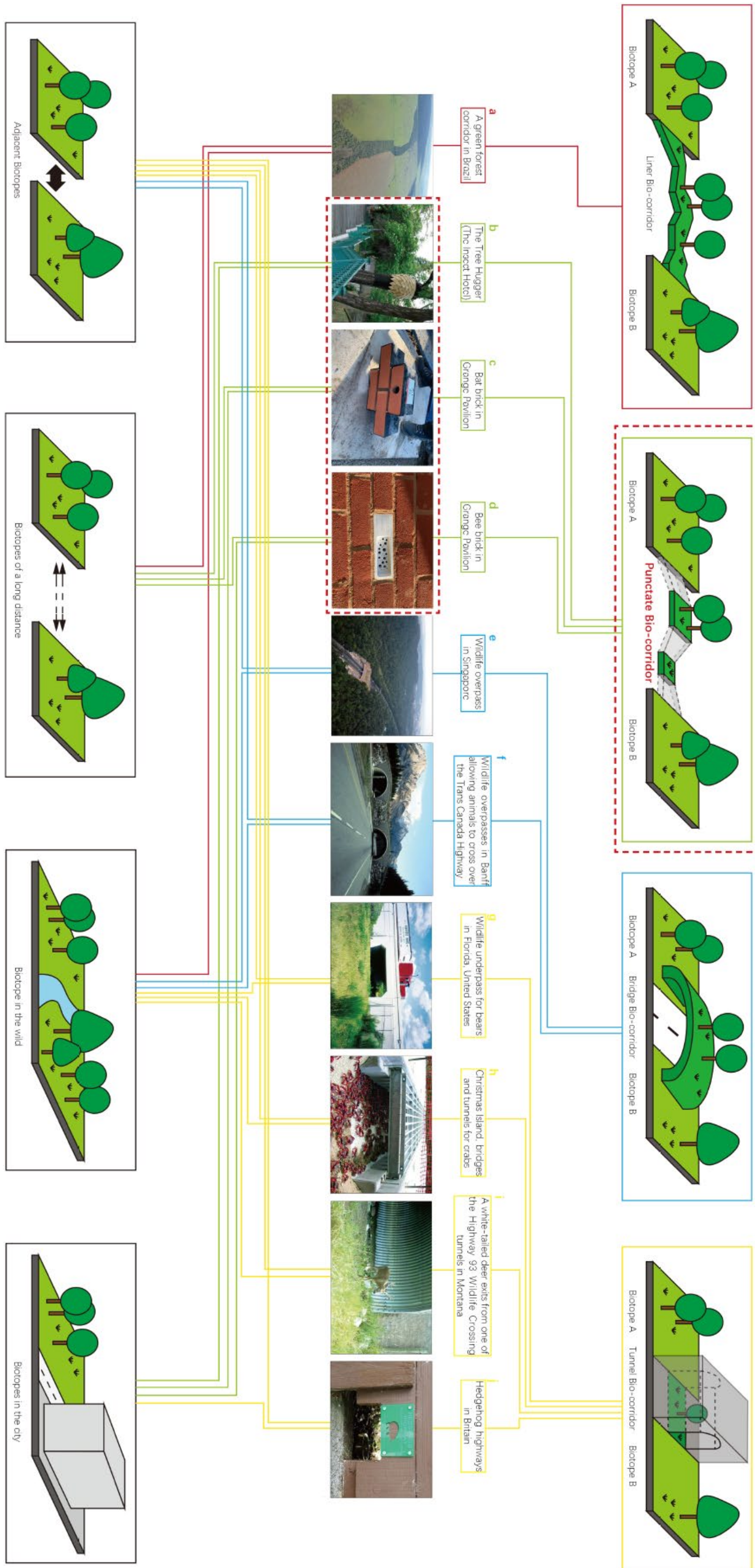


Figure 21 Analysis of precedents of bio-corridor (Image: Wang, 2020; Photo a: Laury Cullen Jr, 2011; Photo b: Robert Carrithers, 2017; Photo c-d: Author, 2019; Photo e: Benjamin P. Y-H. Lee, 2014; Photo f: Qyd, 2006; Photo g: U.S. Dept. of Transportation, 2007; Photo h: Lorenzo Brenna, 2016; Photo i: Josh Lew, 2015; Photo j: The Hedgehog Street Team)

3.10 Case Study: The Greener Grangetown

Greener Grangetown is a sustainable drainage system project located in Grangetown, Cardiff where the research district of the paper is. The project covers 12 Victorian streets and 550 properties (Susdrain, 2018) (Figure 22). It is also designed to promote the quality of the public space and improve the bicycle and pedestrian infrastructure in the city centre neighbourhood (Wenger, 2017). An assessment run by ARUP (2017) shows that multiple benefits could be achieved after the construction of project (Figure 23). It could create a more resilient urban sewer network and a more attractive and useful street environment for residents and commuters (Wenger, 2017).

Figure 22 12 Victorian Streets of the Greener Grangetown Project (Wang, 2020)

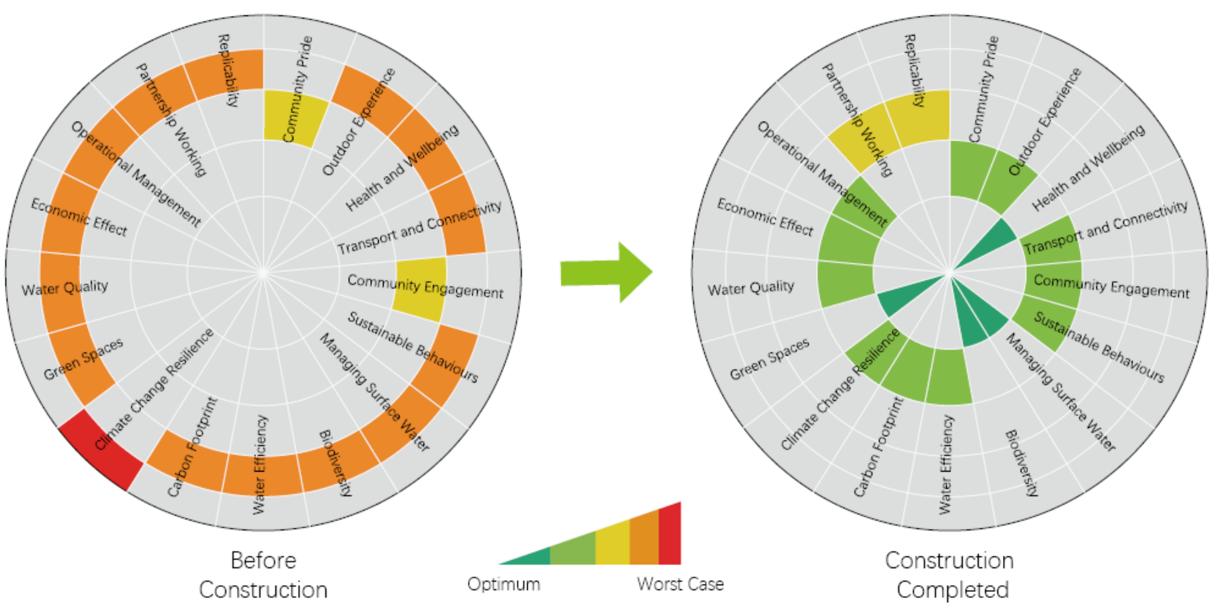


Figure 23 Magnitude of Multiple Benefits (Redrawn by Wang based of the ARUP 2017 diagram)

In the project, 108 rain gardens are created and 130 trees are planted (Wenger, 2017). The area of green space increases significantly. The newly added green spots could effectively divide the migration distance of urban wildlife into shorter ones (Figure 24). Instead of long-distance migration, wildlife could have a break in those green rest spots. Some of the spots could even become settlements for small animals like squirrels and hedgehogs. The project could be an inspiration for urban bio-corridor research.

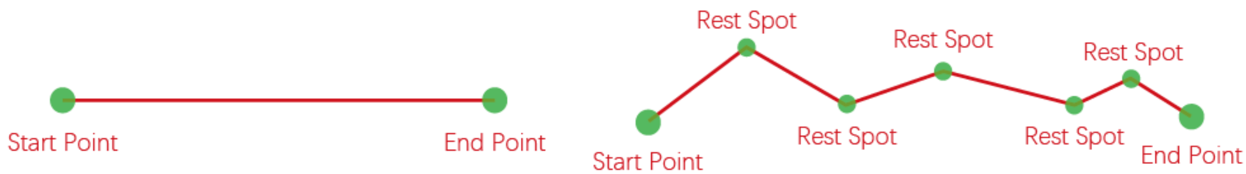


Figure 24 Change in Migration Pattern (Wang, 2020)

3.11 Case Study-COLridor Project

COLridor is a present trans-disciplinary community environmental project which aims to generate a situation of eco-systemic co-living across local species and the abiotic agency in an urban environment through their co-design (Davidová & Zímová, 2018). There are mainly two parts in the project (Figure 25), which are the prototype called TreeHugger (Figure 26) and the public interventions including the giga-mapping codesign workshop, the Seed Bombing workshop, the public speech and others (Figure 27).

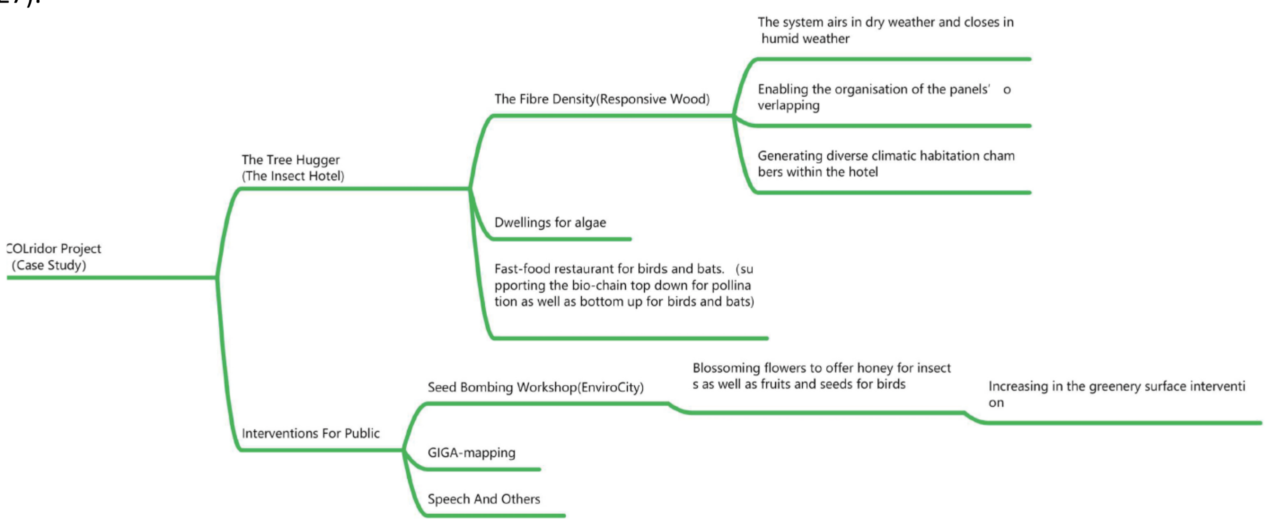


Figure 25 Framework of COLridor Project (Wang, 2020)

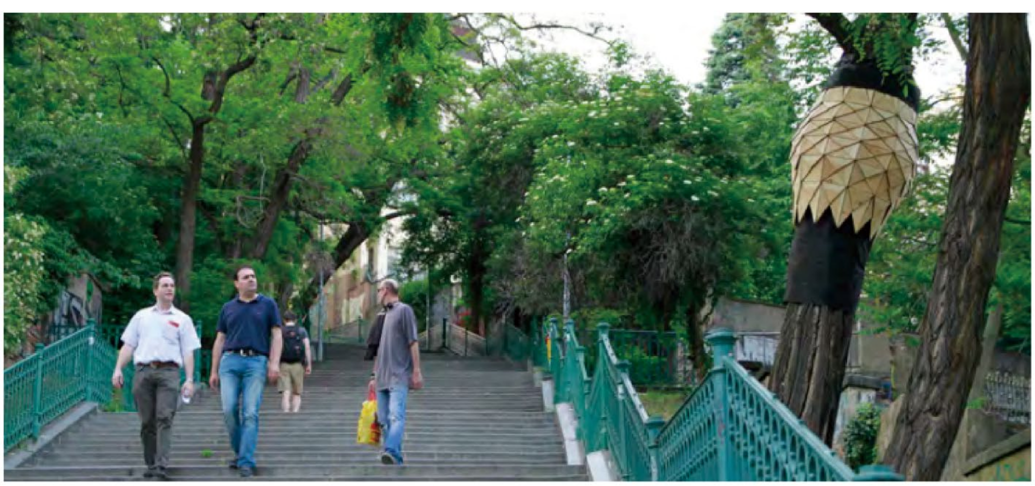


Figure 26 TreeHugger (Photo: Carrithers, 2017)

Giga-mapping Codesign Workshop (Photo: Davidová, 2017) | Seed Bombing Workshop (Photo: Carrithers, 2017) | Public Speech (Photo: Michálková, 2016)

Figure 27 Public Interventions

The prevailing opinion of European urbanists is that cities should remain dense and separate from the rest of nature while landscape ecologists and biologists tend to disagree (Davidová & Zímová, 2018). Most Urban facilities are design for human and non-human species might be overlooked in the city. The relation between human being and non-human species could be conflict or co-existence (Figure 28). The COLridor project team attempted to involve the public in the design and maintenance of the prototype to awaken people's desire to protect nature. When people participate in the design and production process instead of accepting design results passively, people can better understand the spiritual core of the project.

Figure 28 Conflict or Co-existence of Human Beings and non-human Species (Wang, 2020)

As the most important part of the project, the prototype, TreeHugger, plays the role as a medium linking concrete architectural skills and abstract humanistic ideas which are scalable. By using natural materials, the prototype has become a paradise for plants and algae. Naturally, the prototype attracts a lot of birds and bats as the insect hotels are appreciated nutrients for them. It could reach a conclusion that installation created for wildlife should follow the principle of the edible landscape (Figure 29). Foraging is the most basic driving force for wildlife behaviours.

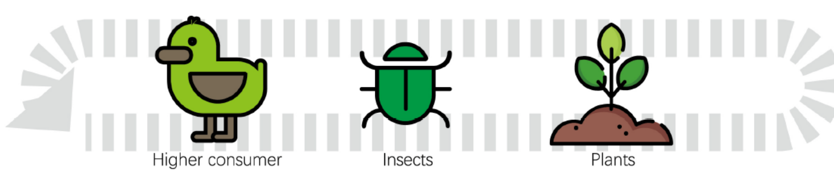


Figure 29 Edible Landscape (Wang, 2020)

In the Synergetic Landscapes project, it is a good idea to generate prototypes with codesign process, and local people could make it themselves. At last, all the prototypes could become an edible landscape system.

3.12 Bio-corridor solution in Grangetown

3.12.1 Urban strategy of bio-corridor

The bio-corridor in the wild is usually of big scale and it could be a linear habitat itself (Figure 30-a). Species such as plants, reptiles, amphibians, birds, insects, and small mammals can spend their entire lives in this linear habitat. In this case, the corridor must include everything that a species needs to live and breed, such as soil for germination, burrowing areas, and multiple other breeding adults (Beier & Loe, 1992). As for the bio-corridors in the city, they are smaller and more scattered. Because of the existence of urban roads, many corridors are made up by several continuous points instead of simple liner green space (Figure 30-b).

A general proposal of punctate bio-corridor has been pointed out to connect potential biological corridors in 3.9. There are many dotted green spaces in the city. As in project COLridor (Davidová & Zímová, 2018), if these green points are distributed linearly and dense enough, they may be regarded as an abstract liner bio-corridor (punctate bio-corridor). Now the number of these green spots are not enough, and the distribution of them should be reorganized (Figure 30-c). The design aim of this paper is to create a general prototype to take the role of the green spots so that the number of spots will be increased and the distribution of them will be adjusted (Figure 30-d).

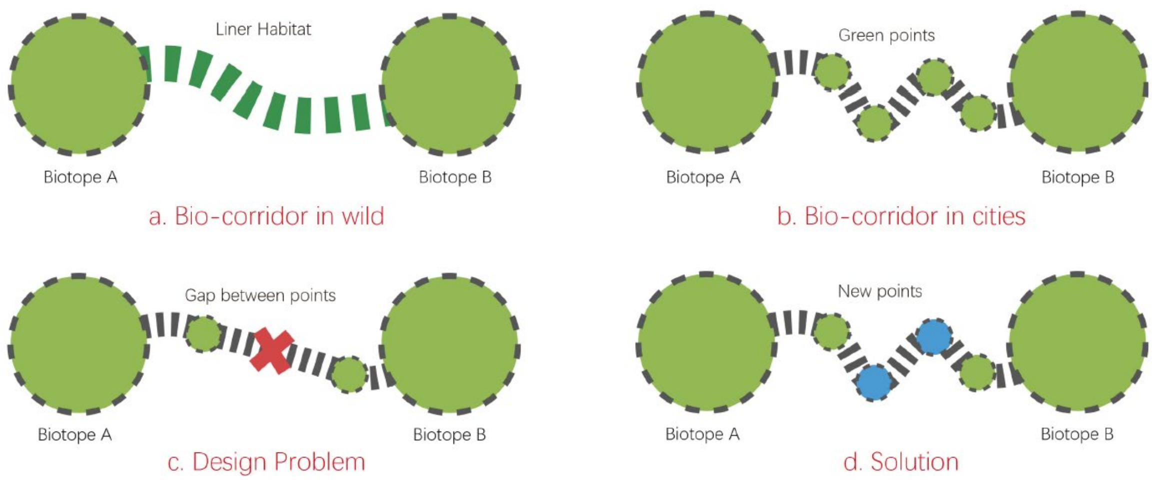
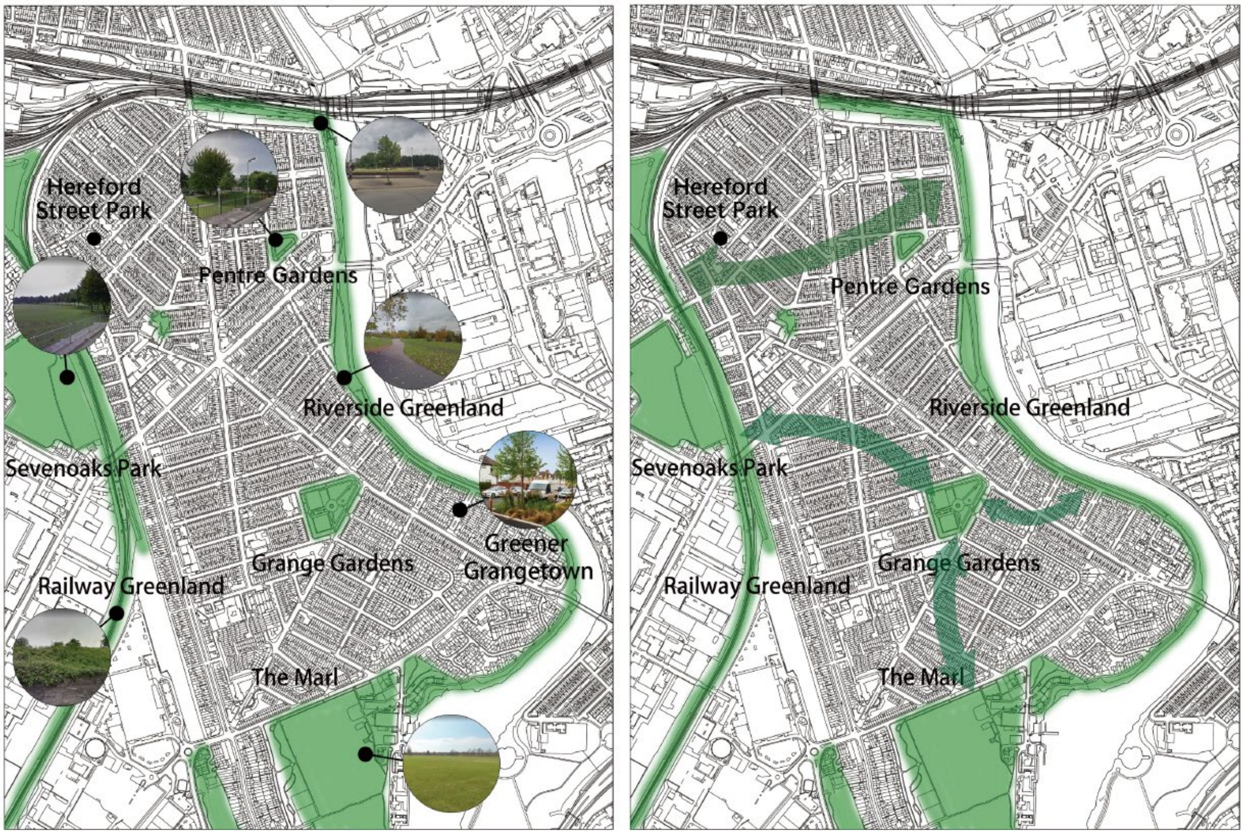


Figure 30 Urban strategy of bio-corridor (Wang, 2020)

3.12.2 Main bio-corridor directions in the location

In the research district (the residential area of Grangetown), Grange Gardens, Hereford Street Park and Pentre Gardens are the only big green space, but there is a green circle around the research district which is made up with several green lands (Figure 31-a). In terms of location and scale, Grange Gardens is the biological centre of the area. Therefore, the main question might lie in how to connect the biological centre with the surrounding green circle. Based on rough site investigation, it is assumed that four bio-corridors could be planned to connect Hereford Street Park and Pentre Gardens, Grange Gardens and Sevenoaks Park, Grange Gardens and Riverside Greenland, and Grange Gardens and the Marl (Figure 31-b).



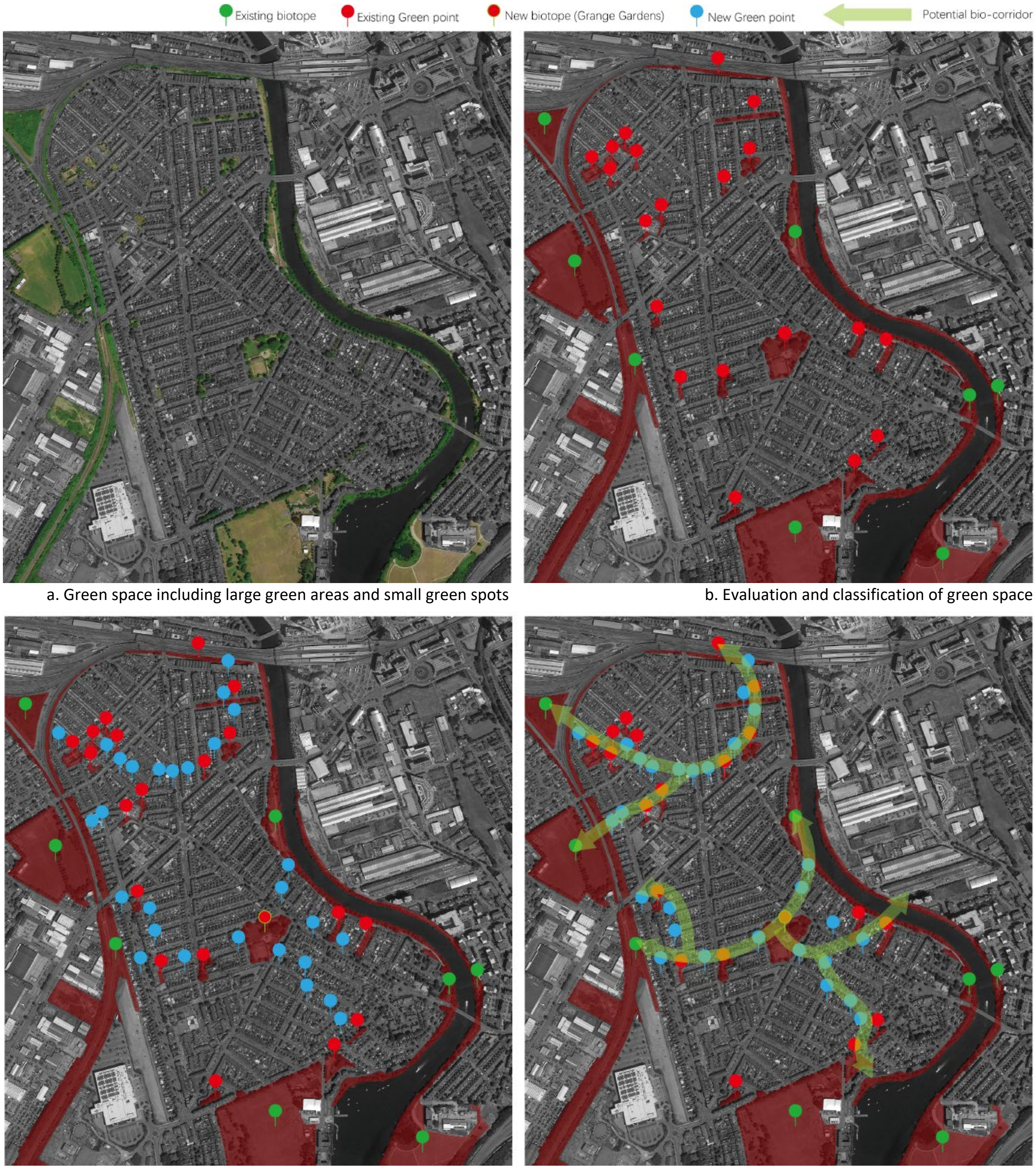
a. Distribution of big green spaces b. Three main directions

Figure 31 Main Bio-corridor Directions (Author 2020)

3.12.3 Potential bio-corridors in Grangetown Speculations

Based on all the contents of previous research, creating punctate bio-corridor would be the basis for the urban solution which has been presented in 3.12.1. The paper has determined the basic direction of the biological corridors, considering the existing sizeable green space in 3.12.2. In this section, the four potential bio-corridors will be detailed. The whole process will use the data from field surveys and Google Earth.

The first step of mapping the potential bio-corridors is to highlight the green area in the whole neighbourhood. (Figure 32-a). Secondly, all the green spaces are evaluated and classified through on-the-spot investigation. The area which could be a biotope and the area which is just able to be a green spot are marked in different colours (Figure 32-b). Taking several factors into consideration, like the size and biodiversity, most areas surrounding the research district could be biotope. Some of parks, house backyards and street trees could be regarded as green spots. In step 3, the evaluation and classification results will be revised. Grange Gardens, which is in the centre of the bio-corridor system should be modified to be a biotope, and more new green points should be added to the neighbourhood (Figure 32-c). Finally, several potential bio-corridors are drawn to link the main biotopes by connecting all the green spots (Figure 32-d). It is important to note that it is a conceptual design based on actual research. The urban solution has certain practical significance, but it still needs to be further optimized and modified.



a. Green space including large green areas and small green spots
b. Evaluation and classification of green space
c. Revision of evaluation and classification result
d. Connection of potential bio-corridors

Figure 32 Potential Bio-corridors in Grangetown (Wang, 2020)

3.13 Participation of residents-Online Collective Map

Codesign is an integral part of the Synergetic Landscapes project and so is the cocreation of the bio-corridors. The main author is the only member of the project team in charge of the research branch, bio-corridor, so the participation of residents plays a vital role in the rationality and universality of the final research result. The online collective map website was created to engage local people in the research of the potential bio-corridors through their DIY. Six prototypes have been designed and made into DIY recipes. Local residents can join the DIY Competition by scan the QR code in the poster in Figure 64 (4.8 DIY Competition).

Firstly, the user needs to use the link or scan the QR code to enter the website (Figure 33-a). Secondly, the user should log in the account (Figure 33-b). If it is the first visit of this online map, the user needs to register (Figure 33-c). Thirdly, the user needs to choose the map style according to the preference (Figure 33-d). Fourthly, the point of the user's backyard could be added to the map (Figure 33-e). Fifthly, the user could upload the picture of the backyard and leave a comment for the project (Figure 33-f). At last, a final collective map will come into being, and the points of the user will be marked in red while those of others will be in green. It should be mentioned that all functions of this map are available on the computer, but on the phone, the user could only read without editing.

Figure 33 The Steps of Using Online Collective Maps (Wang, 2020)

3.14 Redefinition of the research question and aim

Based on the research and solution of the urban bio-corridor in Chapter 3-Research on Bio-corridor, the research question and aim are redefined as the basis for Chapter 4-Design Process of Possible Fabrication. The Research Question and Aim are developed from the urban level to the 'prototypical urban intervention'(Doherty, 2005) level (Figure 34). In the next chapter, how to generate a prototype which could answer the research question and aim would be present. The prototype should be multi-shape to in fit in different sites and multi-function to meet the request of different species.

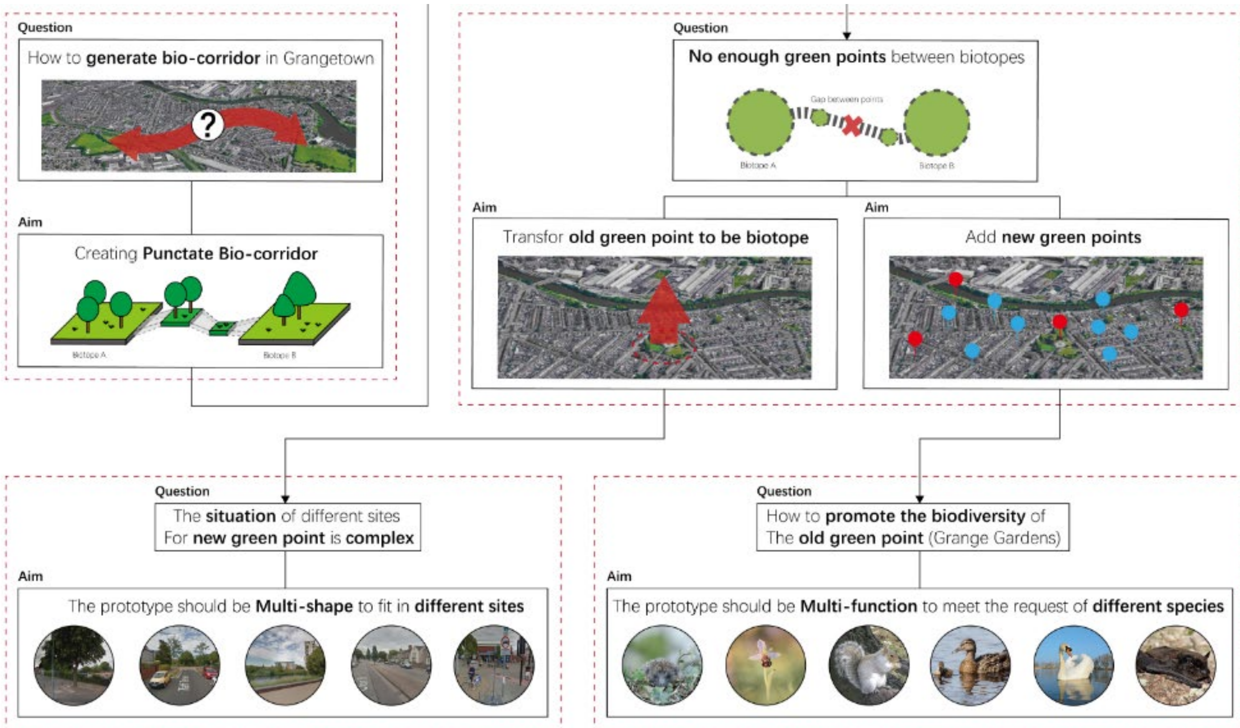


Figure 34 Redefinition of the Research Question and Aim (Wang, 2020)

4. Design process of Possible Fabrication

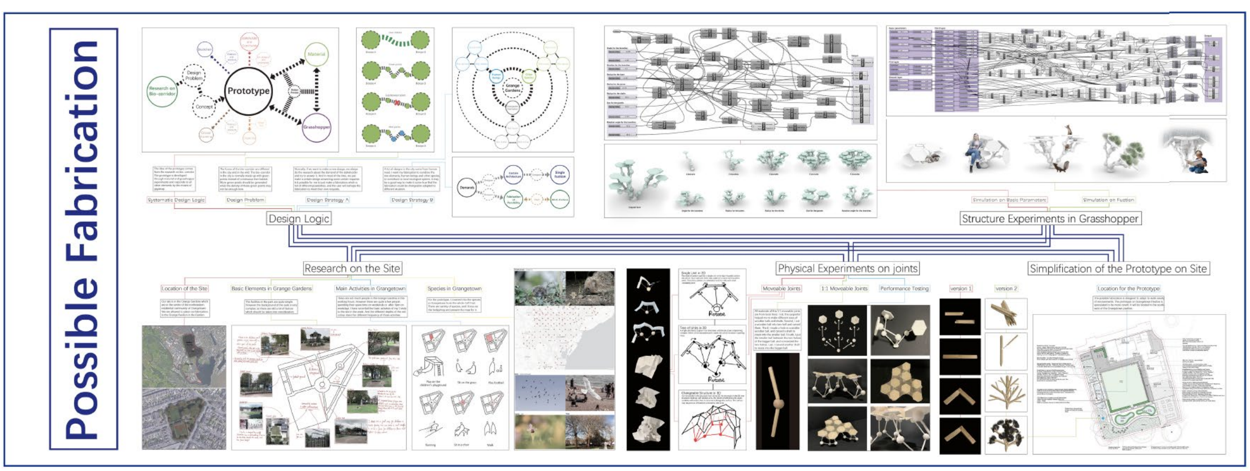


Figure 35 GIGA-map of Possible Fabrication (Wang, 2020)

4.1 Design aim and strategy of Possible Fabrication

4.1.1 Design aim of Possible Fabrication

As mentioned in 3.14, the prototype, Possible Fabrication, should answer the design aim which is to promote the biological level of Grange Gardens and to increase the number of new green spots. Possible Fabrication would be placed in Grange Gardens and the site where new green spots should be (Figure

36). The paper will focus on the design process of Possible Fabrication in Grange Gardens and its installation for the spots will be supported by the co-design and DIY process with local people.

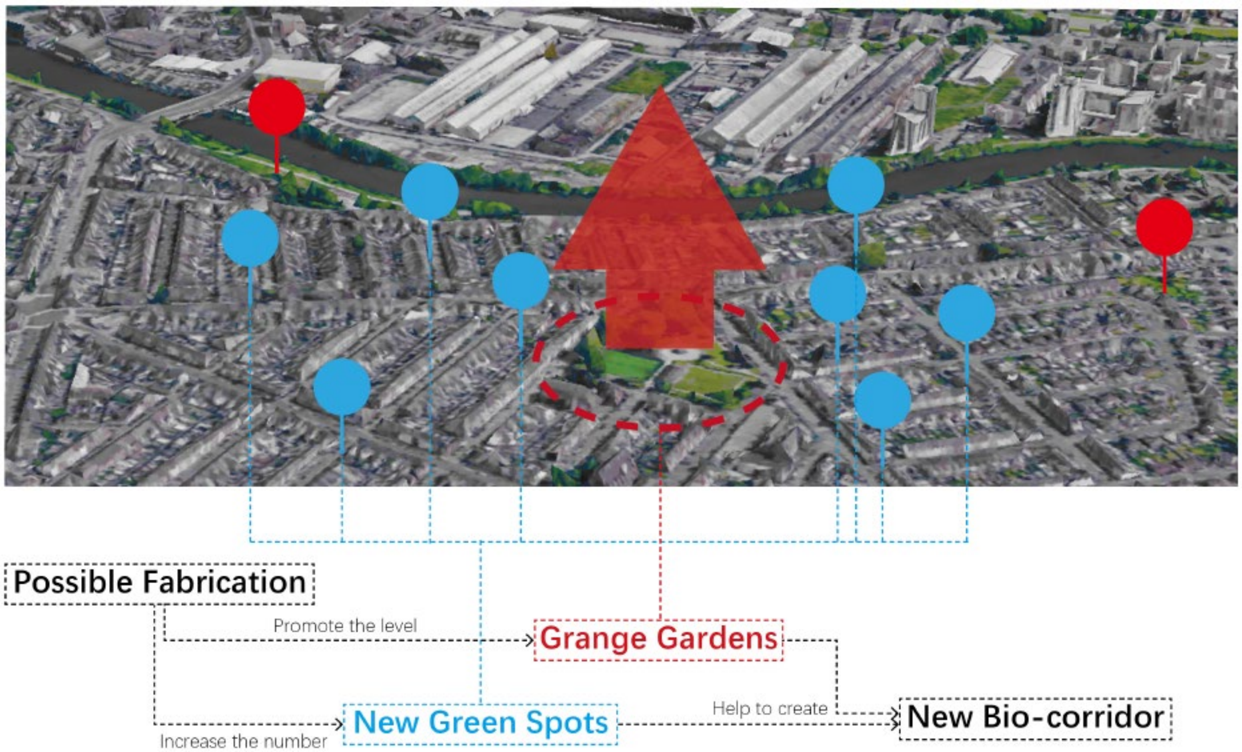


Figure 36 Design Aim of the Possible Fabrication (Wang, 2020)

4.1.2 Design strategy of Possible Fabrication

In response to complex demands of human and urban wildlife, Possible Fabrication is designed to multi-function with changeable and modular structure (Figure 37). Instead of single function, the prototype could change its function with the needs of the users (Figure 38). How to make the structure changeable is the core of design process.

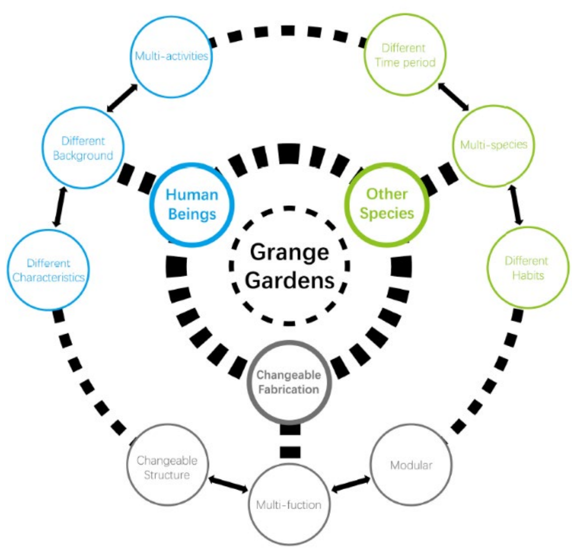


Figure 37 Design Strategy A (Wang, 2020)

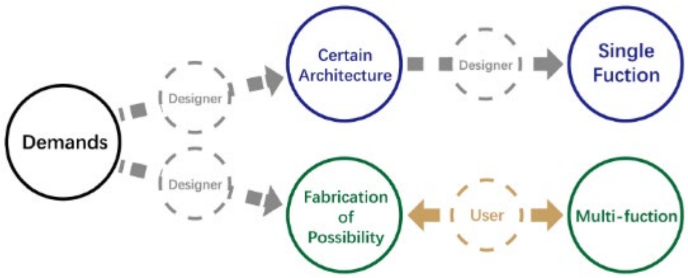


Figure 38 Design Strategy B (Wang, 2020)

4.2 Human research-stakeholder interview

A field interview has been conducted in Grange Gardens among different groups of local people (Figure 39). The information of the interview is summarized into five influence factors, namely, safety, function, nature, synergetic system and community activities. The interviewees hope that the park can meet their diversified needs. They expect the park could offer a possibility for them to get closer to the nature and even play with some non-aggressive wildlife. The whole system of the park run by the government or non-governmental organization should be safer and more efficient. With the completion of the community centre, more community activities of different kinds would be held. The prototype will be designed to contribute to the formation of the synergetic system of Grange Gardens.

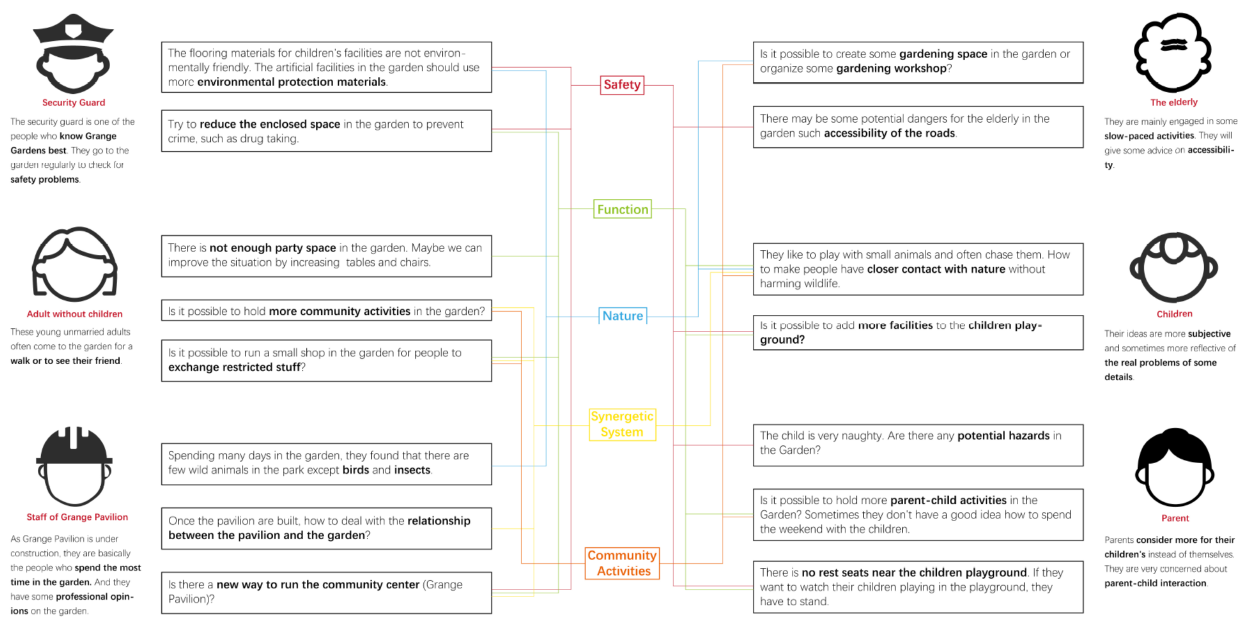


Figure 39 Stakeholder Interview (Wang, 2020)

4.3 Biodiversity of the Taff Trail Research

The Taff Trail is a multi-purpose route between Cardiff Bay in the south and the Brecon Beacons in the north. The trail runs for 55 miles (88km) through a variety of landscapes from the more urban to rural areas (the Council's Countryside Team 2018). Located along the trail, Grangetown are rich in the biodiversity. The main species of the trail are shown in Figure 40. This part of biological research covers a relatively large area and it will be zoomed in in 4.4.

Figure 40 Biodiversity of the Taff Trail (Redrawn by Wang from the image by the Council's Countryside Team 2018)

4.4 Biological research-common species in Grangetown

This part of the biodiversity research focuses on the common species in Grangetown (Figure 41). Hedgehogs, bees, squirrels and bats have been existing in Grange Gardens and those species in the neighbourhood are possible to migrate to it. Therefore, the prototype, Possible Fabrication, could target the six species. For example, the prototype could play the role as the shelter for the hedgehogs, the playground for the squirrels and the hive for the bees.

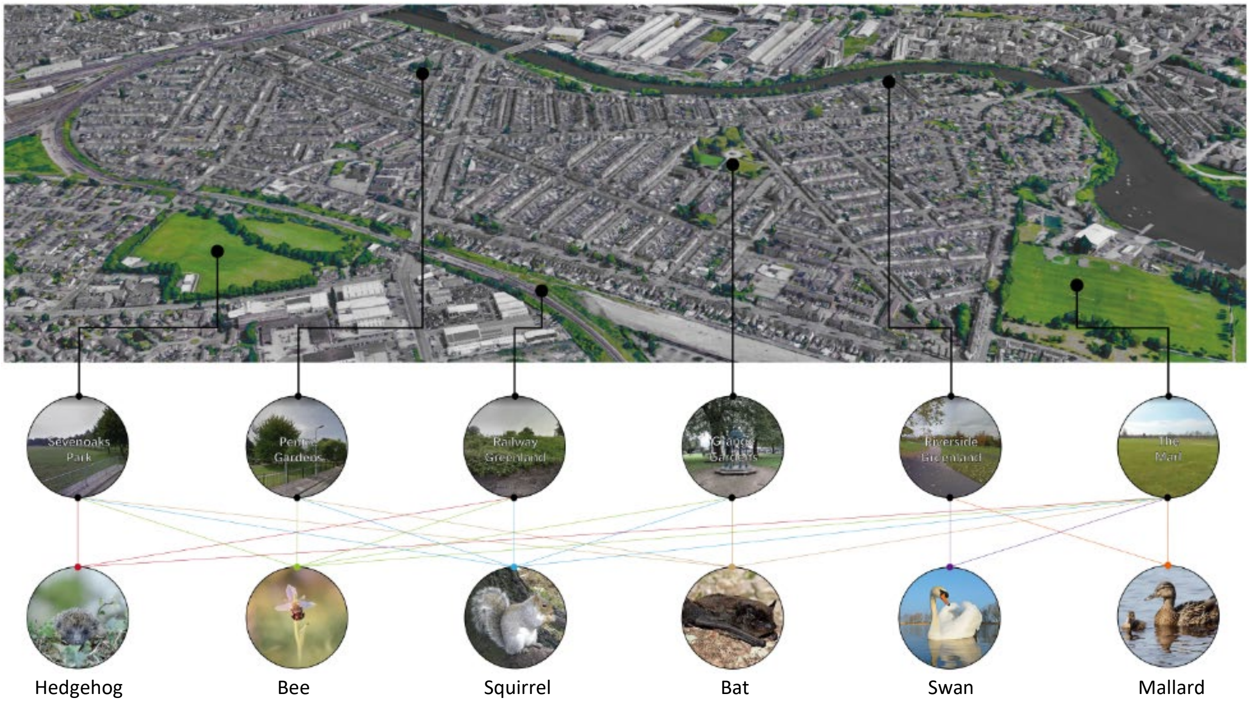


Figure 41 Common Species in Grangetown (Wang, 2020)

4.5 Design process

4.5.1 Design steps of Possible Fabrication

Based on the research in Chapter 3, the design aim for the prototype has been decided. In order to answer it, several experiments with paper will be run to test the changeable structure and the movable joints. After that, the experiments will go deeper in Grasshopper to simulate different situation of the usage scenarios. At last, the prototype will be simplified to be a DIY version through codesign process with local people. The final prototype would be possible for local residents to reproduce in their backyards or other green space (Figure 42).

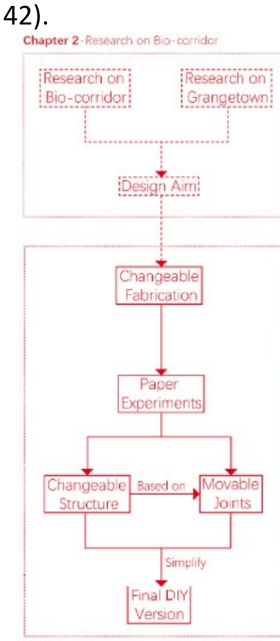


Figure 42 Design Steps of Possible Fabrication (Wang, 2020)

4.5.2 Paper Experiments-Changeable Structure

Paper of the same size is folded in different ways following certain rules (Figure 43). Through the toughness of the paper itself, the structure created is changeable. However, the material of the prototype is difficult to reach the deformation degree of the paper, so the structure of the prototype cannot move when the joint is fixed. Therefore, the prototype will rely on moveable joints to achieve changeable structure.

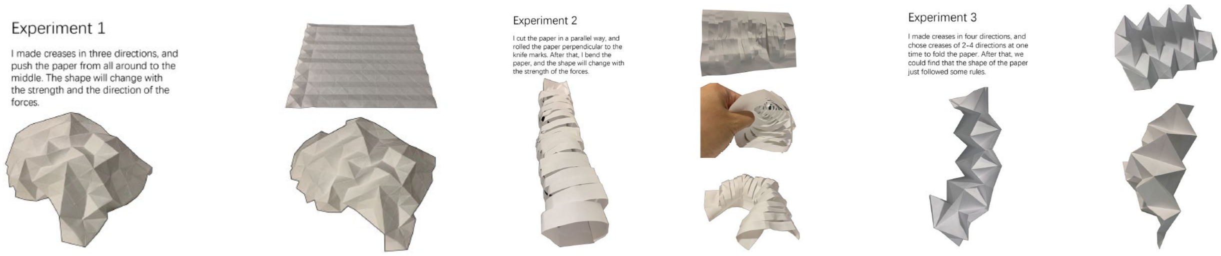


Figure 43 Paper Experiments - Changeable structure (Wang, 2020)

4.5.3 Paper Experiments-Movable Joints

Clay is used in the paper experiments to work as the movable joints. The structure of the prototype changes with the rotation of the sticks on the clay ball (Figure 44). If we replace the simulated material with the actual material like wood, the structure should still be feasible. How to make movable joints needs to be further tested which would be the key for the changeable structure.

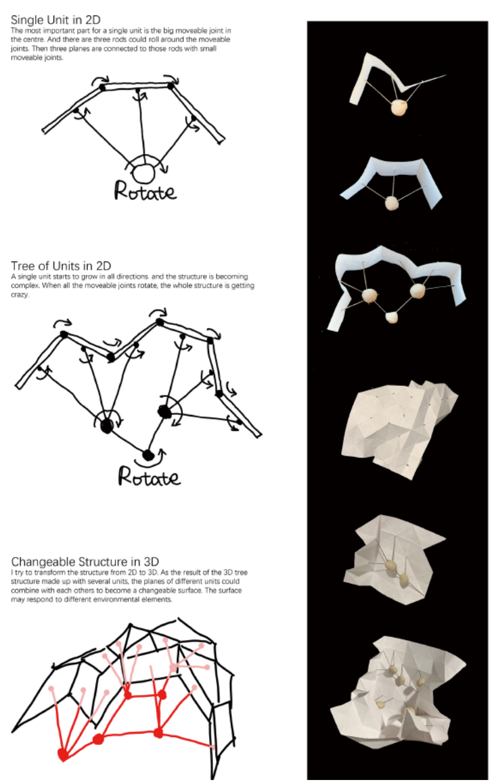


Figure 44 Paper Experiments - Movable joints (Wang, 2020)

4.5.4 Structure Experiment in Grasshopper-Simulation on basic parameters

Based on the basic tree structure, several control groups have been set up with different variables including the number of the branches, the angle for the branches, the radius for the joints, the radius for the shafts, the size for the panels and the rotation angle for the branches (Figure 45). These control groups have been assessed according to several factors which are flexibility, concealment, height, area and stability (Figure 46). From all the control groups, a structure of 3 branches is selected as the basic form for the simulation on function whose values are relatively balanced in all assessment factors.

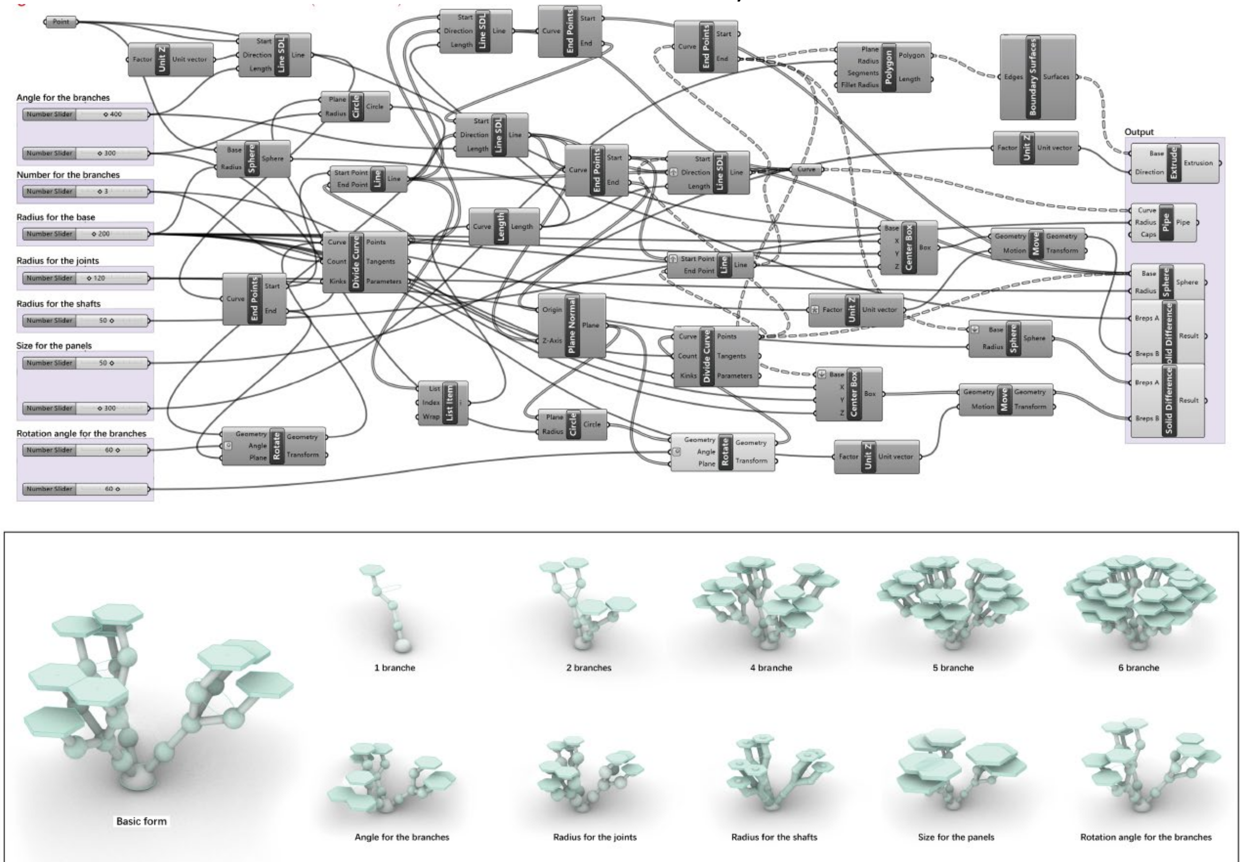


Figure 45 Simulation on Basic Parameters (Author 2020)

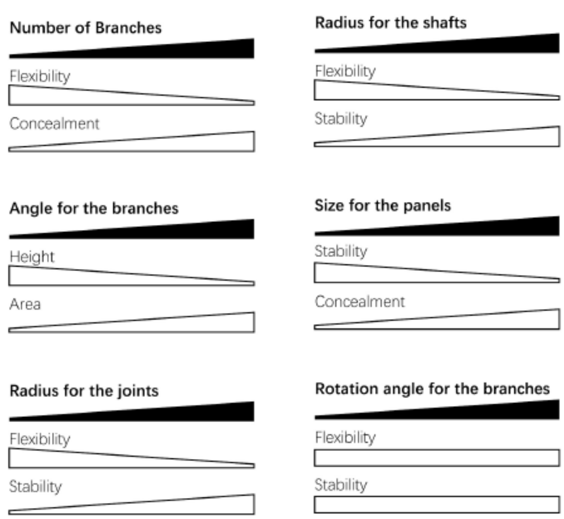


Figure 46 Assessment Factors (Wang, 2020)

4.5.5 Structure Experiment in Grasshopper-Simulation on function

The basic form of 3 branches from 4.5.4 is tested in this section by changing different parameters of the model (Figure 47). With the change of the parameters, the prototype modifies itself to serve for different scenarios, some of which are presented in Figure 48. A conclusion could be drawn that it is possible for the prototype, Possible Fabrication, to fit in different situation with the changeable structure. At this point, the abstract design of the structure is basically completed, and the design will go to the joint to make the structure feasible in 4.5.6 and 4.5.7.

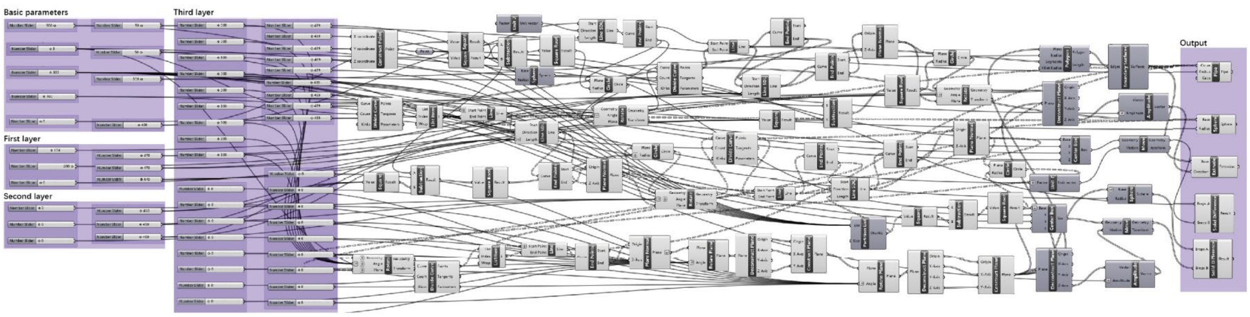


Figure 47 Simulation on Function (Wang, 2020)

Shelter for hedgehog | Seats for human | Playground for squirrels | Heliotropic panels for plants | Secret space for children

Figure 48 Different Scenarios of the Simulation (Wang, 2020)

4.5.6 Physical Experiments on Ball Joint

The first joint is called Ball Joint which is an original movable joint by the main author (Figure 49). The video of the demonstration, which is made by the main author, can be seen by scanning the QR code (Figure 50). The structure of the joint is simple but hard to make. In Figure 49, one shaft is connected to a solid ball, and the other to a larger hollow ball. The solid ball is inside the hollow ball and not able to be taken out. The distance of the two balls is certain, but they can rotate relatively. With the movable structure, the prototype made of it could be changeable (Figure 51). This joint is very flexible, but it has a disadvantage that it cannot maintain a certain angle.

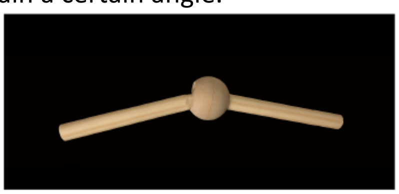


Figure 49 1:1 Physical Model of Ball Joint (Wang, 2020)

https://youtu.be/syVqUNptORE

Figure 50 Demonstration of Ball Joint (Wang, 2020)

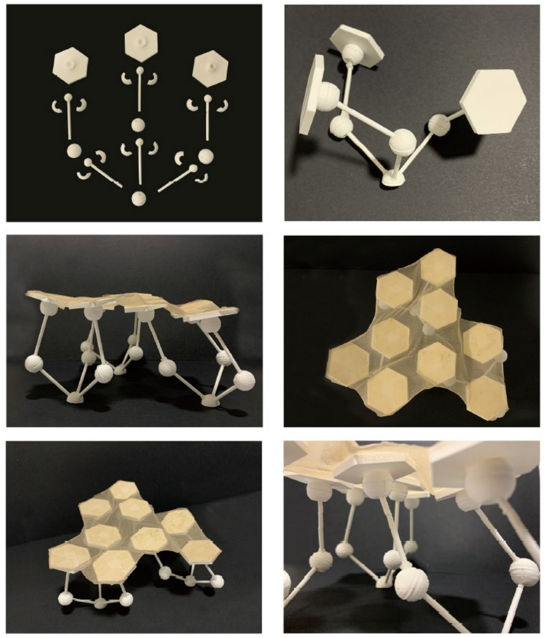


Figure 51 Performance Testing (Wang, 2020)

4.5.7 Physical Experiments on Joint Kawai Tsugite

The second joint is called Kawai Tsugite which is a traditional three-way Japanese joint (Figure 52). The video of the demonstration, which is made by the main author, can be seen by scanning the QR code (Figure 53). The structure of the joint is complex and hard to make. The ends of the two shafts are carved into a certain shape with special teeth (Figure 52). With the joint, the two shafts could fit to each other in three directions (Figure 54-a). The main author creates a new version by changing the angle of the teeth (Figure 54-b). Although Joint Kawai Tsugite cannot rotate freely like the ball joint, it could be transformed among eight forms (Figure 54-b).

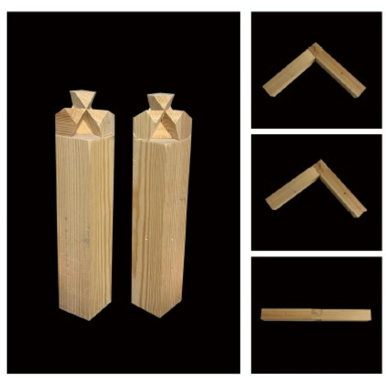


Figure 52 1:1 Physical Model of Joint Kawai Tsugite (Wang, 2020)

https://youtu.be/VDseoEll8LY

Figure 53 Demonstration of Joint Kawai Tsugite (Wang, 2020)

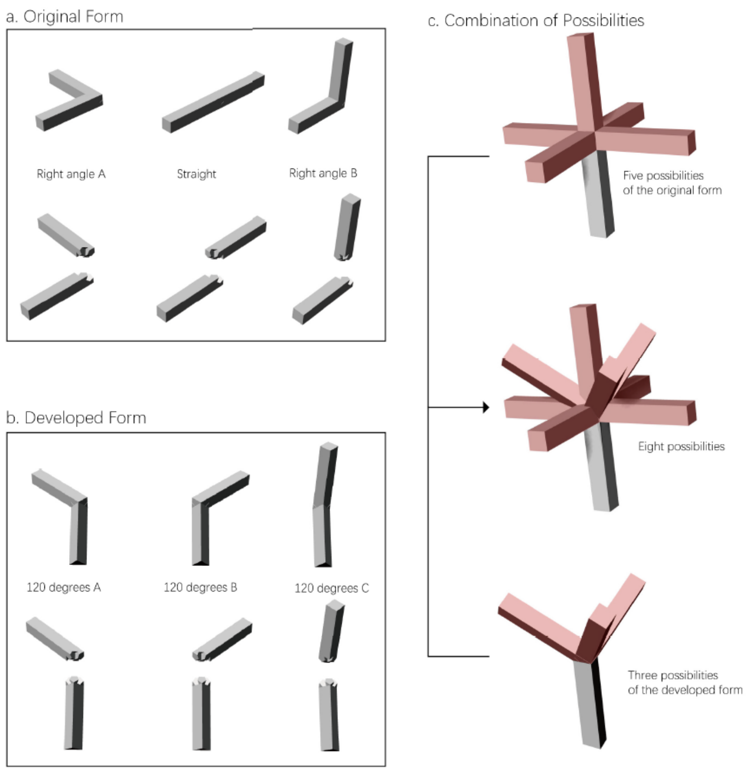


Figure 54 New Version of Joint Kawai Tsugite (Wang, 2020)

4.5.8 Simplification of Possible Fabrication

In order to make it much easier for local people to DIY at home, the fabrication has been simplified (Figure 55). The main structure is made up by branches which you can collect in the park or your own backyard. As for the panels in the fabrication, you can use old wooden boards from your old furniture to make some. If the users have no access to wooden boards, they can create the panels by using branches and willows. In Figure 56, the general construction process is presented. The DIY process of the simplified version is more feasible than that of the movable version (4.5.4-4.5.7). The actual construction steps will be presented in 4.6.

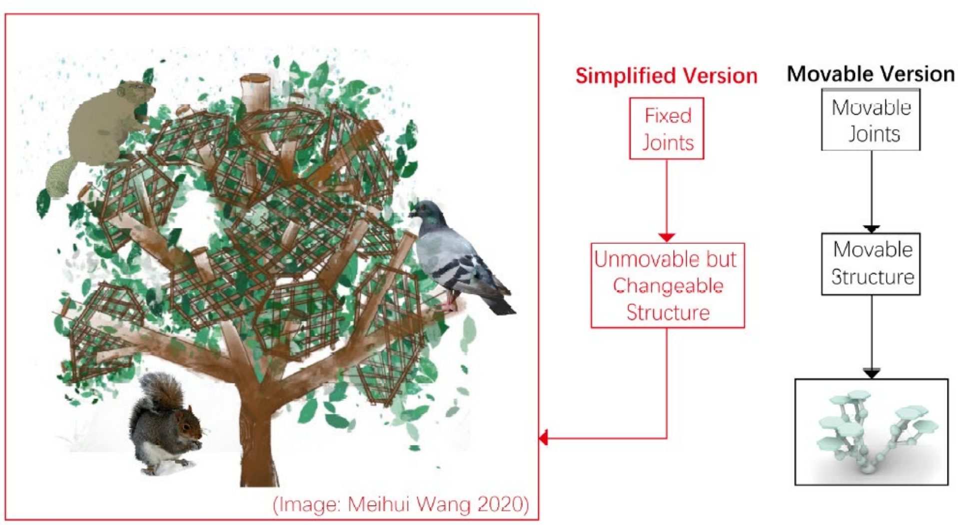


Figure 55 Simplification of the Possible Fabrication (Wang & Wang, 2020)

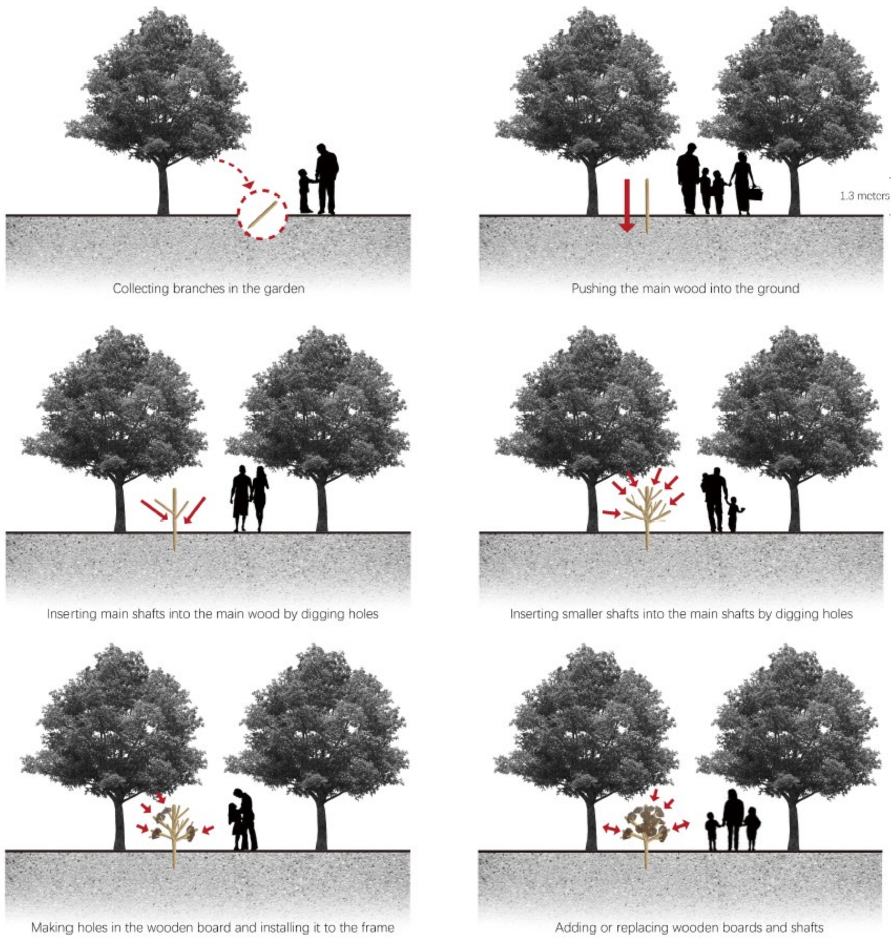


Figure 56 General Construction Process (Wang, 2020)

4.6 Actual construction process of Possible Fabrication

The simplified version of the Possible Fabrication has been built by the main author. The structure of the prototype is proved to be buildable. The simplified version is not movable, but it could grow bigger or change shape by adding or replacing branches. The production cost and fabricated difficulty are greatly reduced, but it still has certain environmental adaptability. The simplified version can be better spread among the residents with the help of online tutorial (Figure 57) in this special period of COVID-19.

The actual construction of the first prototype is showed in Figure 58. The tutorial video, which is made by the author, can be seen by scanning the QR code (Figure 57). Local people can install the prototype freely to meet their own demands due to the simple construction process and easy access to materials. All the materials of the prototype are easy to get. The builders just need to collect some branches and willows in the park or their backyard. By following the actual construction steps, they could build the prototype step by step.

https://youtu.be/DhO7Q5ISCC8

Figure 57 QR Code for the Tutorial Video (Wang, 2020)

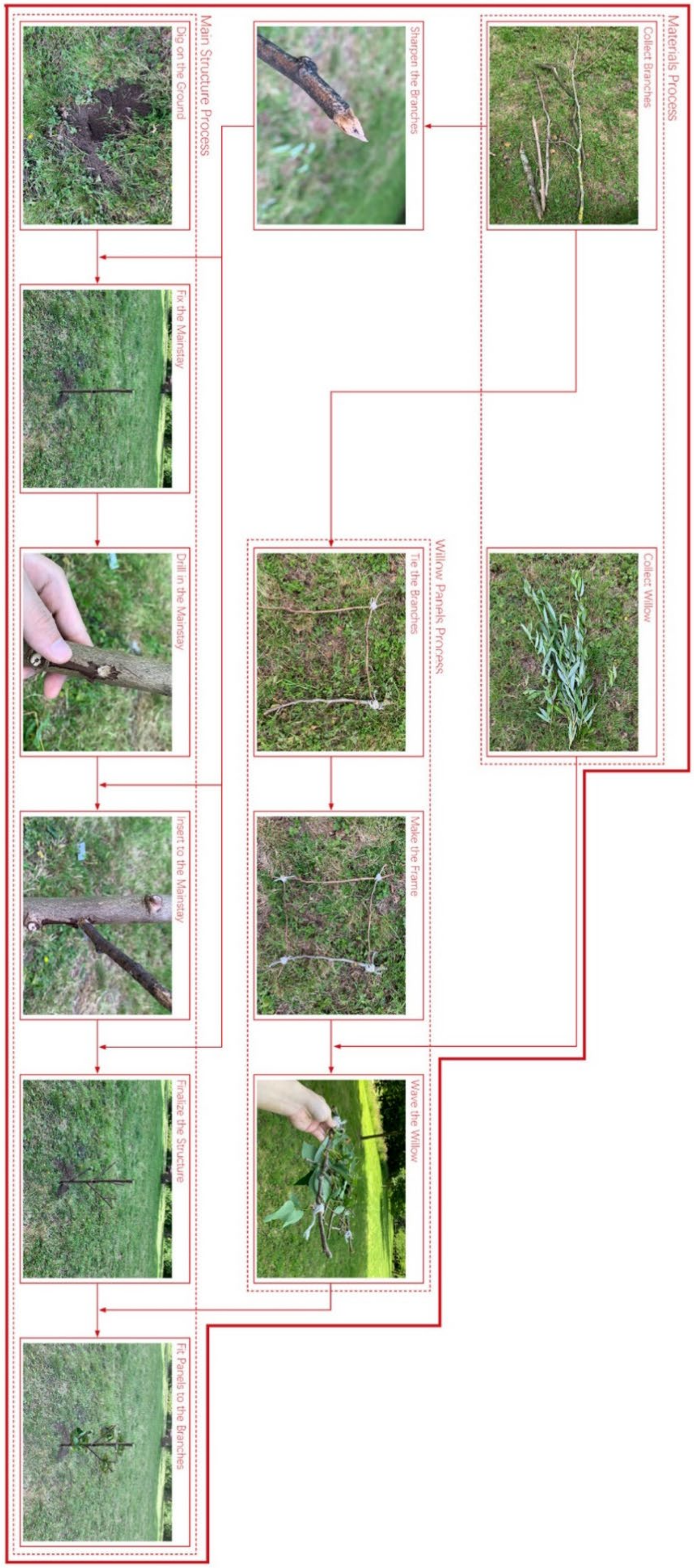


Figure 58 Actual Construction Steps (Wang, 2020)

4.7 Codesign process

Codesign is very important in the whole design process (Figure 59 - Figure 63). In the early stage, the project team communicated with local residents and experts in other fields to form our theoretical system and come up with our design aim. After researching on the research district and the research branches, and codesigning with stakeholder and teammates, the six prototypes were generated. And in the later stage, the project team got the feedback from local people about our project and tried to modify it.

For the main author, local people have offered suggestions on how to simplify the Possible Fabrication to be a DIY version (4.5.8). Their opinions were also referred to in the selection and use of final materials.

Figure 59 Introducing the project and modifying our prototypes with local people (Photo: Davidová, 2020)

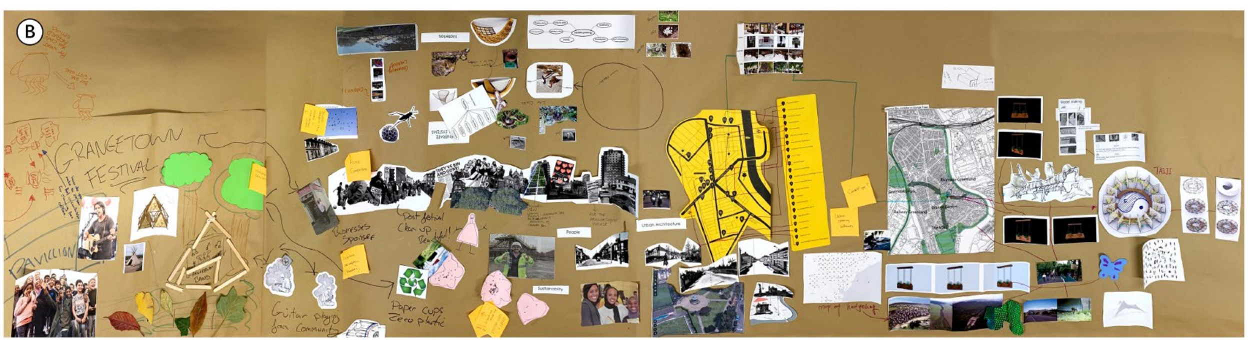


Figure 60 Codesigning with local people about how to improve Grangetown (Photo: Wang, 2020)

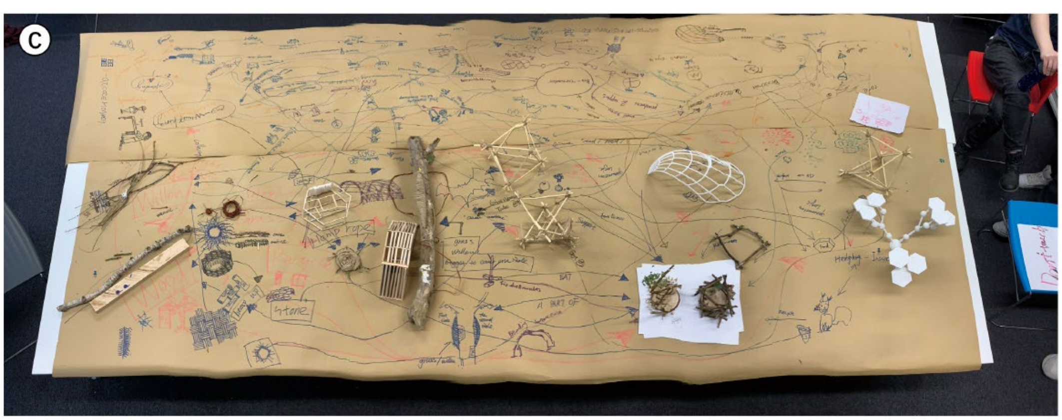


Figure 61 Codesign with teammates about the interaction among our prototype (Photo: Wang, 2020)

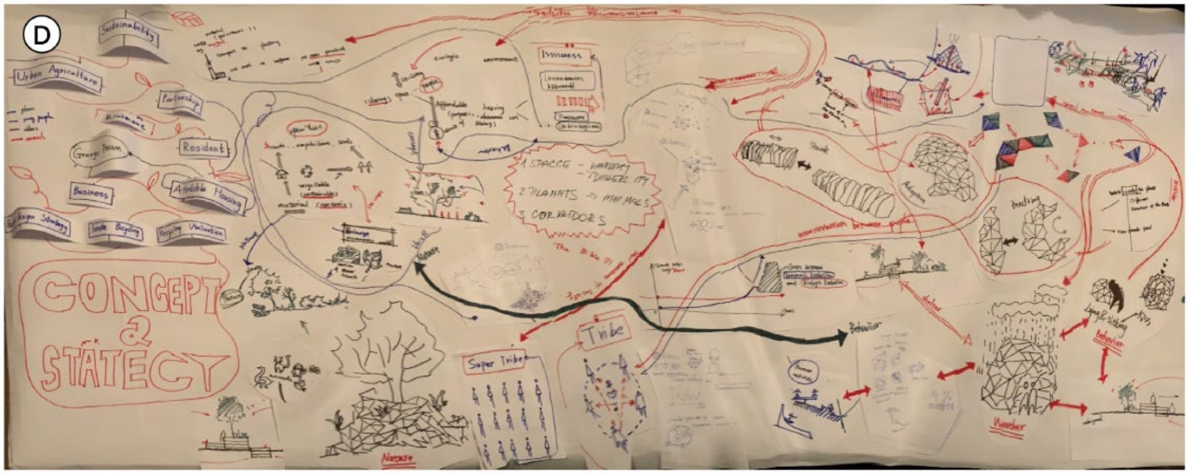


Figure 62 GIGA-mapping about design concept and strategy with Landscape Ecologist (Photo: Wang, 2020)

Figure 63 Codesign workshop with stakeholders (Photo: Wang 2020)

4.8 DIY Competition

In order to engage local people in the DIY process of the bio-corridors generation, a DIY competition was held online (Figure 64). The aim of the competition was to encourage people to use natural materials to create liveable spaces for other species in the backyard. Participants could receive Tokens that can be exchanged for gifts from local small businesses.

Figure 64 Poster for the DIY Competition (Wang, 2020)

By installing and DIYing all six prototypes in Grange Gardens including Possible Fabrication, Eco-metropolis, Deadwood Home, The Growing City Game, Mallard Nest and Hidden Bat Box, a biological system is formed (Figure 65). The waste materials of one prototype could be used in the expansion of other prototypes. Some prototypes are designed for animals, and the manure of those animals can be used as fertilizer for other prototypes. The prototypes that are nourished by fertilizer are mostly plants, which can provide food back to those animals. The circulation in this system does not rely on human intervention, but on animal instinct itself.

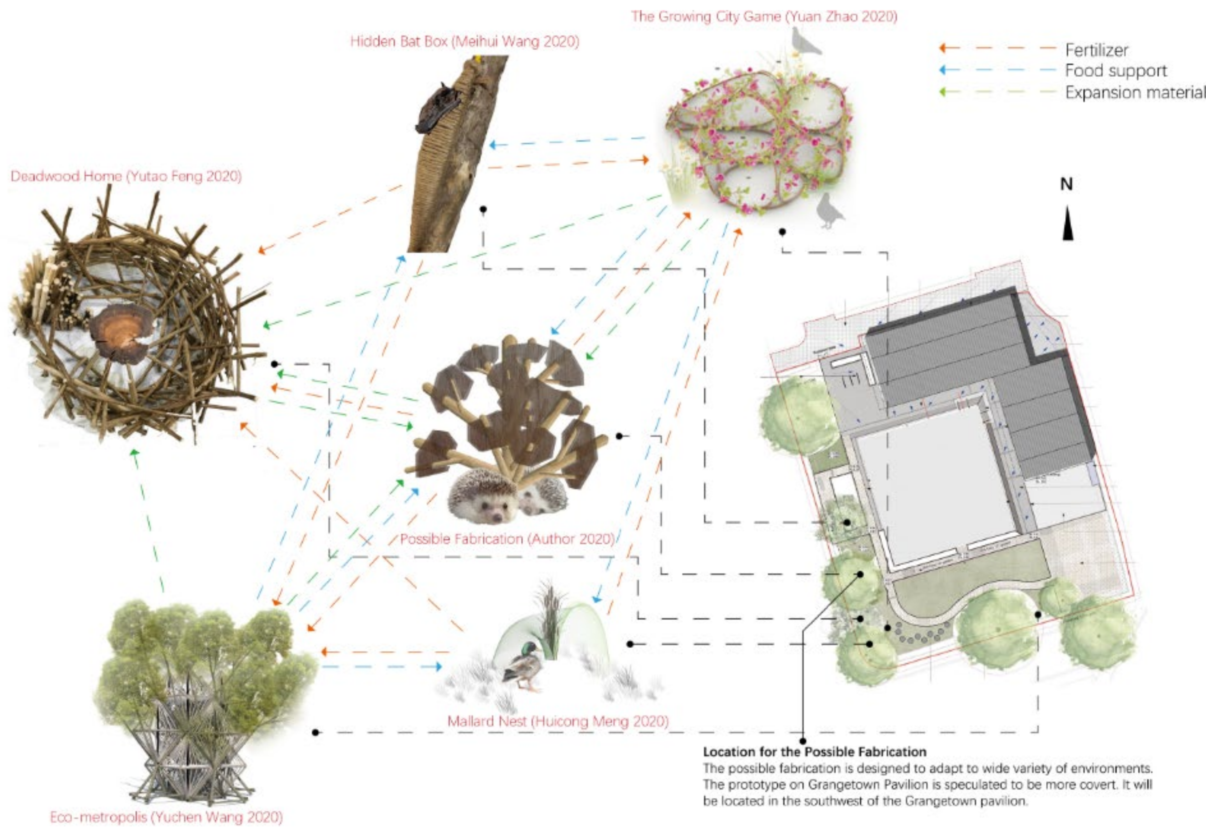


Figure 65 Biological System in Grange Gardens (Wang, 2020)

5. Conclusion

This paper discusses how to generate urban bio-corridors in Grangetown to deal with the biological isolation of urban wildlife. The design research consists of two main parts, the development of the urban strategy and the design process of the prototype, Possible Fabrication. Based on the diagnosis of the context of Grangetown, the definition of the research gap and the analysis of the literatures and precedents, a new form of bio-corridor is pointed out by the authors that is called punctate bio-corridors. In order to generate punctate bio-corridors, new green spots are planned to be connected as potential bio-corridors generated through cocreation. Through the biological research, the material and structure experiments, the codesign process and the DIY competition, Possible Fabrication is designed to adapt to different environments and demands, which could serve as the green spots in punctate bio-corridors. With increasing urbanization, the human environment and the biological system of the city will be further changed. The urban strategy of bio-corridors should be constantly modified to face the challenge of the times.

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