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Can the Value of Green Infrastructures be Demonstrated to the Government in Shanghai?

- Discover measurements for valuing GI services and solutions to government's valuing challenges

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Being a dissertation submitted to the faculty of The Built Environment as part of the requirements for the award of the MSc [International Planning] at University College London:
I declare that this dissertation is entirely my own work and that ideas, data and images, as well as direct quotations, drawn from elsewhere are identified and referenced

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Abstract

Shanghai is the biggest metropolitan and economic center in China, which has an earlier green infrastructure (GI) development domestically. However, there is limited number of academic literature and no official document focus on the value of GI service in Shanghai. Government's usage of GI service value can inform and improve decision-making frame by regarding GI as economic assets to better maintaining an economic circle and good quality of life.

Currently, Chinese and western scholars have reached a consensus that GI have four services which are provisioning, regulating, cultural and supporting service. The article then discover Shanghai's policy and mechanism to find which GI service have direct relationship with government's finance and with available data. Decreasing temperature, air improvement, water mitigation and land value capture are four services satisfying the conditions and also Shanghai's heated topics. The article then use loss avoidance method, alternative cost method and hedonic method calculate GI's service value to demonstrate whether it is still profitable in Shanghai.

The second parts of the article focus on solutions to current government's two challenges in valuing GI- fund shortage and land restriction. International cities in Singapore, America, Germany, Japan and Korea play an indicative role in discovering solutions. Green bonds and equities, green adoption and naming, encouraging social associations and developing vertical GI are four potential solutions. These will be analysed through people's willingness, mechanism to support and policy to regulate to discover whether these can be applied under Shanghai background. In this term, Shanghai's deficiency will be outlined. After both governments and the public realise and utlise GI's value, Shanghai's green economy will be prosperous.

Chapter 1 Introduction

Shanghai, located in Yangtze River Delta, is the biggest metropolitan as well as the economic centre in China. Similar with most cities in China, Shanghai followed President Mao's 'The Great Leap' strategy in 1958 and focused on light industry development. During that period, urban planning was prepared for industrial layout and transportation (Leaf&Hou, 2006). The over-produced industries and lack of sustainable planning led to the poor urban green coverage. It had been estimated the green space per capita was 0.2m^2, regarded as 'a pair of shoes' (SHG, 2019). After President Deng put forward 'Reform and Opening Policy' in 1978, Shanghai transformed to tertiary dominant sectors, and urban planning started to consider 'strategic plan', which aims at local sustainable and context-based development. The value of urban green was then firstly considered to improve city's image to attract more investors and ensure residents' health. In 1990s, the government spent 8 million Yuan for removal expenses to construct the earliest urban public green infrastructure (GI) in Middle Yan'an Road, and also established a statutory policy for GI management-Shanghai Afforestation and Greening Regulation (SHAGR) in 1987 (SLCAAB and SFB, 2018). Different from most cities in China, Shanghai government realised the importance of GI in last century. Therefore, Shanghai was regarded as green advanced city in China.

GI service value means how much value GI can produce with its eco-system service Gomes and Barton (2013). Shanghai has a better GI development, so that green space per capita increased from 'a pair of shoes' to 'a room'. However, GI's destruction and inappropriate design in these years also show the barrier for the government to valuing GI service. For example, some blind development of GI has already used up the land planned for next 100 years, but now the poor governments have limited fund for maintaining them. The government has to face current challenges for stagnation, thus green economy develops slowly. In Shanghai and even in China, few official document and academic literatures involves the content of discovering local GI's service value, but abundant in the western countries. Mayor of London (2017) established a report to calculate natural capital account for London, aiming at improving and informing decision-making frame by regarding GI as economic assets to

better maintaining a good quality of life and economic circle.

Nowadays, Shanghai also needs such an analysis report urgently to research local GI service value, so that the government will not regard GI maintenance as a burden and can have suitable design to maxmise GI service, which blooms local green economy and GI sustainable development. Therefore, this report is regarded as the starting point in Shanghai to demonstrate GI service value to the government. The research is divided into two parts. Firstly, it will establish current potential measure from international literatures to value GI and discover whether GI service is still profitable in Shanghai. Secondly, the research will also analyse possible solutions from international cases to alleviate current government's challenges, so that the government can step into these valuing measure. At the final part of the report, it will give a conclusion and prospect on potential changes towards GI policies and mechanisms.

Chapter 2 Literature Review

2.1 National and Local Policies towards GI

As Shanghai's GI development starting point is later than western countries, the legal construction work is not as comprehensive as them. The first policy implemented was SHAGR in 1991, which was regarded as the starting point for legalization of GI in Shanghai. SHAGR is the product of planned economy and provides legal protection to local GI development by government (Liu, 2008). However, SHAGR cannot fit in rapid development of Shanghai. The mechanism lacks the third-party monitoring, as it states the green department set preparation, approval and monitoring function in one (SMPC, 2003), so that lacks power coordination and mutual restriction. In addition, SHAGR is thought to be centralised under planned economy as it gives vague range of administrative application in district level. It separated Pudong New District and Puxi old districts, urban and rural area, with different GI quota, which is difficult to mange and coordinates under Shanghai's integrative development.

The government realised the disadvantages of SHAGR and put forward 'Shanghai Green Infrastructure Regulation'(SHGIR) and implemented SHGIR in 2007 which is a decentralised policy to highlight district administration towards GI. SHGIR states GI planning is regulated and funded by secondary government (district government) (SMPC, 2007), which also means secondary government should pay for creating, refreshing and maintenance of GI in their own district. In addition, SHGIR also creates a third-party constituted by the public and authorities such as property, finance and water affairs (SMPC, 2007). In order to support integrative development, SHGIR deletes separated criteria and regulates all newly built residential and commercial project should include at least 35% coverage of GI (SMPC, 2007), which can also avoid fund flows to commercial and property development only. However, both SHAGR and SHGIR do not establish the mechanism and criteria to connect GI with official's record. GI cannot generate real capital value directly, which increases local GDP like commercial property. This become a potential element to create barrier for government valuing GI.

GI funding mechanism is also mentioned in SHGIR that each government should create GI

project budget with GI experts, and the fund cannot be used for other purpose (SMPC, 2007). The competition for the project's fund is through competitive bidding mechanism (SMPC, 2007), which creates a transparent and fair green market by information sharing. The interview from professor. Li mentioned current factor to decide amount of fund got in GI project is nursery stock's amount and size (3 feet or 15 feet). Although it is reasonable consideration reflecting GI's construction and maintenance cost, this mechanism overlooks GI's service value which may decrease the benefit of GI service to environment as well as green economy development. Seriously, it also causes some unsustainable design such as extremely intensive GI and merely pursuit of GI number to get more fund but increasing GI's decaying speed.

2.2 Current Challenges in Shanghai GI Planning

The literature shows Shanghai's GI develops quite unequal especially between urban districts and suburban, rich district and poor district (Yu et al., 2016), shown in picture 2.2. Although Shanghai has an urban green coverage 38.2% currently, some urban district has very low green space per capita, such as Jing'an only has 0.96 (Liu et al, 2012), which is far below comfort standard (shown in table 2.2). The first reason is that, in old urban district, most space is defined as reserved area to protect historical infrastructure (Liu et al., 2009) which is recorded in urban masterplan and regulatory plan. The second is the main reason, as professor. Li pointed out that Shanghai's GI planning and implement in some districts is greatly restricted by financial problem, which leads to poor maintenance and refurbish. SHGIR contributes to an integrative development, but government with poor finance is difficult to reach that criteria. Some district such as Xuhui and Huangpu have a large income with international business tax, bustling commerce and higher land price, while others like Hongkou do not have the same business amount as CBD area, and their land price is cheaper due to living environment, transportation and business there. Therefore, maintaining and creating GI is really a burden for them due to the limited income, and it is hard for them to realise the capital value of GI because the value chain has been broken if they do not have enough fund. In addition, current system also makes the poor government, as GI are not recorded into their grade but they must spend money to reach 35% green coverage, so that they cannot discover

what actual capital value GI services can bring to them but only struggle to reach the objective. Therefore, current system is still in defect to provide barriers to GI service value recognition.

District	Green Space Per Capita (m^2)	Notes	District	Green Space Per Capita (m^2)	Notes
Huangpu	1.37	Urban	Minhang	24.71	Suburban
Jing'an	0.96	Urban	Baoshan	18.9	Suburban
Xuhui	4.63	Urban	Songjiang	11.31	Outer Suburban
Changning	6.37	Urban	Jiading	23.59	Outer Suburban
Yangpu	3.74	Urban	Qingpu	29.42	Outer Suburban
Hongkou	1.81	Urban	Fengxian	13.46	Outer Suburban
Putuo	5.15	Urban	Jinshan	15.48	Outer Suburban
Pudong New District	24.2	Suburban	Chongming Island	11.69	Outer Suburban

Table 2.2 Data of Shanghai green space per capita (Liu et al., 2012)

Picture 2.2 Appearance of current Shanghai GI development (SHG, 2018)

The second challenge is the restriction of land for GI development in urban Shanghai (Cheng, 2008). As mentioned in the introduction, Shanghai has already used up the land planned for next 100 years, there is limited land for future GI development in urban area. This is partly caused by SHAGR's no third-party's monitoring, which let capital flow to property development

beyond control.

2.3 International Case Studies for Solving Funding and Land Shortage Problems

Green Bonds and Green Equities

Singapore is regarded as one of the greenest cities in the world, having 50% green coverage (Cheng, 2008). In order to support local committee to manage a large amount of green space and implement 'National Park Ordinances', the government launched MAS Green Bond Grant scheme to create a long-term green capital market with depth and liquidity, which aims at encouraging foreign issuers of green bonds. This method has drawn large interest among Singapore corporations and financial institution. For example, the Singapore Exchange sought to set itself as the green bonds' leader and list corporations in the market (SIIA, 2017). After first Asia Pacific Green Bond was hosted in 2013, 27 green bonds worth more than $15 billion were listed (SIIA, 2017). Similar with equities, international corporations such as Malaysian-listed and Thai-listed corporations also follow mandatory exchange rules in ASEAN equity markets in order to get qualify for green labelling and degree of their greenness (SIIA, 2017). These can be a win-win situation as the committee can get a large amount of fund to alleviate their pressure on maintain GI in Singapore, while the corporations can get reputation as the assurance on the product and services from green labelling, so that the corporations' value are boosted. An important element for the success of Singapore's GI management is the comprehensive policies and mechanism to regulate the implementation of green bonds and equities. At the same time, social awareness of GI in Singapore is also essential, as it can draw attention of GI and be more potential to establish a stable green capital market.

GI Adoption and Naming

Derived from last section, GI in urban area can be named and owned by the private. Other city such as Wenzhou in China has already put forward that individual is encouraged to adopt local GI in 'Regulations on urban greening in Wenzhou'. After GI adoption, the individual will get adoption certification as well as naming right (WZPCC, 2017). Except Wenzhou, though other cities such as Suzhou and Haikou do not list GI adoption and naming, activities for GI adoption especially during

autumn are usually held by local authorities. This action privatlise GI and let individual take care of it by personal support, which decreases government's financial burden on managing local GI. At the same time, person who names local GI will also get reputation for future development. This is regarded as a win-win cooperation.

Encouraging Social Association

In America, the government has no right of intervening private green space. If the owners of the green space has difficulties in controlling and maintaining GI, some social associations or professional groups will help the landowners to manage GI, such as American Association of Botanic Gardens and Arboreta, Society of Municiplal Arborists, Utility Arborists Association and American Forestry Association (Liu et al., 2006). The fund for social associations in America comes from governmental funding, social fundraising and membership's fee (Liu, 2008). Such associations improve self-management of community GI, which decreases governments' roles on managing and funding local GI. However, this method should also base on strong regulations and social awareness. In America, 'Urban Forest Law' approved by National Congress, together with 'Common Law' launched in 1972 were used to regulate and control GI development (Liu et al., 2006). In 1978, the National Congress, referred to Cooperative Forest Law Clause in local level, established '1978 Cooperative Forest Funding Law' to provide criteria to control forest development, and it also highlights the mechanism of providing funds and technology to associations (Liu et al., 2006). At the same time, the social associations also aim at promoting the value of GI to the public to get more social responses.

Encouraging Vertical Green in Busy Area

One potential way to handle land restriction problem in urban busy area is to use vertical green. The western countries have integrated vertical green's urban ecological service and economic benefit to rich urban regeneration space and deal with heat island effect, which jumps out of urban land restriction (Liu, 2008). In global scale, there are two methods for government to encourage vertical green. One is giving incentives for vertical green development. For example, Germany government provides 25% of total GI construction fund, and 15 €/m^2 vertical green sewage charge.

At the same time, the government also decrease 50% fixed assets tax for the owners of vertical green (EPA, 2014). In Korea, Seoul's 'Regulations for the protection and the promotion of green space' indicates the government will compensate 50% green roof construction cost (Liu, 2008). In America, New York city government also encourage vertical green by compensating FAR (Liu, 2008). Another method is to set rules by government to control vertical green development. A case study from Japan shows the Tokyo, Nagoya, Osaka and Kyoto government set the rule that new buildings covering more than 1000m^2 should have at least 20% roof area for planting GI (Liu, 2008). Therefore, this section indicates that government's intervention on vertical GI can promote social motivation on building a greener urb, and discover the potential room for GI in central area.

2.4 Government-Related GI Services and value evaluation

The first theme to demonstrate GI's value is to review the existing literature about what services GI can bring to human life. Both Chinese and western researchers have the same conclusion, as Gomes and Barton (2013) and Zhang et al. (2010) claimed that GI belonging to one important element in ecosystem, has regulating services, provisioning services, cultural services and support services, shown in picture 2.4. Meanwhile, the research should be focused on services that can demonstrate value to the government, so some of the services focusing merely on society's value should be overlooked. The government-related services can be described as followed.

Picture 2.4 Ecosystem Service (WENP, 2016)

For regulating services, the first function is to decrease temperature and alleviate urban tropical island effect. As Gomes and Barton (2013) pointed out vegetation's transpiration can absorb heat from nearby environment and scatter internal water to the air. In addition, GI such as mega-phanerophyte can also provide urban shade which has effect on cooling and humidifying. According to 120 green space tests in Shanghai, megaphanerophyte's height between 5-8 meters will reduce 2.0℃(Gao et al., 2013). The cooling function can decrease government burden on high temperature allowance. In 2018, Shanghai government revised 'Measures for the administration of heat prevention and cooling' that each worker should get ¥200 per month if the temperature is over 33℃ (SHHRSSE, 2019). It has been discovered that Shanghai had overall 4 months which has at least one day over 35℃ in the summer of 2018 (SMS, 2018). If the urban temperature decrease 2.0℃, the government will pay less 2 months' allowance for workers in government-established companies. To calculate GI's value on cooling, both The Mersey Forest (2018) (TMF) and Xie et al. (2015) relates to saving energy cost. It is logical when calculating how much energy cost can be saved if the temperatures decreases 2.0℃ without manmade facilities. However, this answer is not specified to government as this fee is mostly paid by residents in China, and it is also difficult to calculate in a diversified city like Shanghai, because energy saving cost varies greatly according to the volume. Based on the research, the usage of alternative cost method is a good start, but the alternative should be high temperature allowance, which is more direct to government finance and more relevant.

The second regulating service is air improvement, as GI's photosynthesis can absorb pollutants in the air and release oxygen. In Liu et al. (2009)'s research, they pointed out, as Chinese GI are usually made of Chinese fir, Pinus massoniana and paulownia, 1 hm^2 G1 green space in Shanghai can absorb 900kg CO_2, 88.56kg SO_2, and 380kg NO_x and generates 600kg O_2 per day. It has been estimated through market price method (TMF, 2018) that Shanghai's GI can generate 81 million Yuan oxygen every year, which is more than the salary of all department of GI management-16 million Yuan (Lin, 2012). However, market price method values GI service product by directly putting into market (Industrial oxygen producing)

which means it relies much on market mechanism, and the usage of oxygen in nature is quite different from man-made oxygen. In addition, it is also impossible for officials to trade natural oxygen. Therefore, this value calculation becomes quite illusory. A better method to calculate under Shanghai's background is to relate GI's value to pollutant charge in Shanghai, as indicated by Tanpaifang (2014) that the pollutant charge is decided by the cost of governments' effort on dealing with pollutant in the air. According to the latest 'Chinese Atmospheric Pollution Prevention Law' (NPC, 2015), the pollutant charge for SO2 is ¥0.63/kg, and ¥631.6/t. The measure to calculate GI's value can be discovering how much SO2 and NOx can be absorbed in different districts, and then monetise the amount.

The third regulating service is water mitigation, which is overlooked in large number of literatures towards GI value in China. GI can help the rainfall to spill into the soil or stopped by leaves and tree trunks instead of just fall on asphalt surface in urban area (Liu and Chen, 2018). It means larger volume of water will enter the city sewer, which increases the cost for water management. One case study in America (EPA, 2008) shows the rainfall water generates five times more runoff than woodland area and only 15% water infiltrates into the ground in American city blocks. This topic also remains heated in Shanghai, because as Shanghai Meteorological Service (2019) indicated that the annual average rainfall amount is 1150.6mm, and amount of rainfall increased 11% than 1980s. The rainfall intensity in rainy season also increased 12% than 1980s (SMS, 2019). Therefore, there should be a more giant project to mitigate surface water and prevent flood in Shanghai. TMF (2018) has provided a calculation for GI value by evaluating avoided infrastructure costs, which has direct relationship with government value as Chinese government pay for the establish of sewage system. In addition, it is better to add rainfall water mitigation cost, which is also paid by government, so that GI's mitigation value can lead to the decrease payment from the government. Current sewage price is ¥5.25/m^3, as Water Supplies Bureau (2019) claimed.

Except regulating service, GI can also capture land value in urban area. In the western, CABE's case study shows the property value increases 5-7% higher near green spaces than

similar properties further away. Therefore, the investment of GI can then offer a higher return for real estate. However, Shanghai's land value capture differs largely from western model in property typology, ownerships and economic situation, so that western data cannot be applied in Shanghai. Unfortunately, there is limited resource to analysis under Shanghai's background. The data can be used from Zheng and Mao (2019)'s research which shows GI can increase 3.96% nearby land value in weighted average in China. As the Shanghai's land is public-owned, the government can directly get return from increased land value. TMF (2018) and Gomes and Barton's mention using hedonic value method to evaluate GI's land value capture effect. There is no objection because the research has already pointed out the direct relationship with GI and nearby land price. The mechanism is GI's roles in improving district's image to attract investors and visitors, bringing more willingness to retail and leisure spending. (MerseyRs, 2016).

The gap between this research and literature review is that none of the measures mentioned has been applied to Shanghai before. In addition, the measurement method can use from the previous research, but the topic and data should strongly relate to government's finance, so that it will discover whether the government can have economic benefit from GI service. If GI service is still profitable, it will be a persuasive document to demonstrate Shanghai's GI value to the government. The second gap is though the study from international cases to solve funding shortage and land restriction for GI are both successful, it may still be difficult to implement in Shanghai according to different administrative and social background, so that these case should also be analysed under Shanghai's background to discover what can be revised and what elements can support these cases.

Chapter 3 Method and Data

3.1 Research question and objectives

Inspiration of the research presented here comes from Shanghai's fact that the government, responsible for GI development, usually consider GI development's capital value rather than its ecosystem service benefit, thus limited eyesight focus on establishing a system for measuring ecosystem. This is the reason why Shanghai, even China has a rare literature towards calculating GI's ecosystem service value. Derived from existing western literatures, such as Gomes and Barton's report (2013) about ecosystem services and TMF's report about calculation about ecosystem service value, this research aims at developing a calculation method based on Shanghai's specific background. Therefore, the first research question is how to develop a measurement derived from existing literature to calculate GI's capital value towards its ecosystem service. This measurement should be quantitative to demonstrate how much benefit can government gain from GI, so that the officials will less possible to regard building and maintaining GI as a burden.

Shanghai's GI development period is shorter than western countries, the feasibility may differ largely among different background. From the literature review, two barriers are recognised to governments' valuing GI, which are shortage of fund and land restriction. The busiest districts need the coordination between GI and occupied land. Conversely, districts Chongming, Fengxian and Hongkou, regarded as the three poorest districts needs less burden for building and maintaining GI. Therefore, this research secondly aims at analysing whether international experience is still feasible under Shanghai's background to provide more possibility for alleviating district governments' barriers to valuing GI.

3.2 Methodology

This research can be divided into four stages. The first stage includes reviewing different literatures about Shanghai's background and possible ways for calculating GI value and discovering international examples for removing barriers for the government (described in section 2). This stage also includes finding different kinds of data which is contributed to the

calculation and comparative in the next stage

This second stage will use quantitive method to monetarise how much actual capital value can be produced by GI government-related services by temperature decreasing, air improvement, water mitigation and land value capture. After producing the final outcomes, the value produced by each service will be compared with GI refreshing and maintenance cost to demonstrate GI's value to the government. Study from Liu et al. (2009) indicates that current Shanghai calculation for GI cost usually uses Chinese afforestation cost method to calculate the average price of Chinese fir, Pinus massoniana and paulownia per square meter, which is ¥240.03. In addition, Green Dash (2019) also research current GI average maintaining cost in one year, which is ¥7.25/m^2, constituted by the cost of mitigation, tool, clothing, cleaning, insurance, replacement, clipping, fertilizer, weeding, pest control and tax. Therefore, the formula to calculate GI's cost can be created as followed:

$$C_x = 10^4 S_x (240.03+7.25Y)$$

X means the name of different districts. S_x means the area of total green space in different district, and can be found through secondary data in China Report (2014) in table 3.2.1. Y means the year. Urban green cost then can be calculated as C_x:

District	Total area of GI (Hectare)	Notes	District	Total area of GI (Hectare)	Notes
Huangpu	266.44	Urban	Minhang	8387.04	Suburban
Jing'an	734.88	Urban	Baoshan	6562.45	Suburban
Xuhui	1271.17	Urban	Songjiang	12570.91	Outer Suburban
Changning	1055.09	Urban	Jiading	7643.52	Outer Suburban
Yangpu	1381.71	Urban	Qingpu	10205.92	Outer Suburban
Hongkou	405.03	Urban	Fengxian	9816.91	Outer Suburban
Putuo	1204.61	Urban	Jinshan	8810.08	Outer Suburban
Pudong New District	26519.38	Suburban	Congming Island	27460.49	Outer Suburban

Table 3.2.1 Total area of GI in different districts (China Report, 2014)

Temperature Decreasing Value

Derived from existing literature study, the capital of temperature decreasing can be calculated by using loss avoidance method towards saving cost for high-temperature allowance. Unfortunately, there is no secondary data focusing on district level, but focus on metropolitan level. According to National Bureau of Statistics of China (2018), Shanghai's employees at state-owned units are 1418 thousand, shown in table 3.2.2. Therefore, in this section, the whole Shanghai is taken as the object instead of Shanghai's district, which can also have benefit of overlooking individual employee in some area that is not covered by GI services. In addition, as Shanghai Meteorological Services recorded in 2018, if Shanghai's average temperature decreases 2 ℃, there will be two months (June and September) whose temperature can be controlled completely below 33℃ (SMS, 2018). Therefore, the calculation can be created as followed:

$$V_{Tx} = 2C_t P_g Y$$

V_{Tx} means capital value for temperature decreasing in different district, C_t means cost for high-temperature allowance and P_g means population works in government-established companies in Shanghai.

	Employees at state-owned units *Thousands*	SOE share of urban employment *Percent*
Shanghai	1,418	20%
Beijing	1,857	20%
Chongqing	1,198	24%
Tianjin	812	26%

Table 3.2.2 Employees at state-owned units (NBSC, 2018)

Air Improvement Value

After improving existing literatures with Shanghai's unique background, GI's value of air improvement can be calculated through loss avoidance method towards pollutant charge. As mentioned in literature review, the data indicated by 'Chinese Atmospheric Pollution Prevention Law' (NPC, 2015) that the pollutant charge for SO_2 is ¥0.63/kg, and ¥631.6/t for NO_x. In addition, Liu et al. (2009)'s research also indicated current 1hm^2 Shanghai's GI can absorb 88.56kg SO_2, and 380kg NO_x per day. Therefore, the formula can be created as followed:

$$V_{Ax} = S_x (88.56 \times 0.63 + 380 \times 0.6316)$$

X means the name of different districts, and S_x means the area of GI in different districts.

Water Mitigation Value

The calculation of water mitigation value of GI uses alternative cost method, which is inspired by TMF, to focus on the mechanism of urban water cycle, as mentioned in literature review. A challenges in this section is that the machine cost for mitigation is not available to the public, so that the value of GI in this section is regarded as the amount of money that the government can save from mitigating less rain water due to GI's effect on intercepting the rain. From Liu and Chen's report (2019), the interception per unit area is shown in table 3.2.3. Due to the different interception amount, urbs, suburbs and outer suburbs divided by three ring roads in Shanghai should be calculated separately. However, due to the data availability, there is no resource towards amount of different green area in Shanghai. The solution is to use weighted average in the table to represent common GI's interception per unit area. The amount of the rainfall intercepted is then transformed into m^2 (1mm $\approx 31.42\times10^{-6}\, m^3$). Finally, GI's mitigation value in different area can be calculated by multiplying Shanghai's drainage cost ¥5.25/m^3 (WSB, 2019). The formula can be created as followed:

$$V_{Mx} = I_x S_x \times 5.25 \times 31.42 \times 10^{-2}$$

X means the name of different districts, V_{Mx} means GI's mitigation value in different districts, I_x means weighted average of interception effect in different districts based on located in urban (I=843.47), suburban (I=907.05) or rural area (I= 922.53), and S_x means the area of GI in different districts.

Area (Shanghai)	Weighted average of 1m^2 GI interception effect (mm/year)	Interception's percentage in total rainfall water
Urban	843.47	73.34%
Suburban	907.05	78.87%
Outer Suburban	922.53	80.22%

Table 3.2.3 Rainwater interception in different region (Liu and Chen, 2009)

Land Value Capture

The calculation of GI's land value capture will use hedonic method as Gomes and Barton's mentioned. Gi's land value capture effect is quantified through the increasing land price because of the GI construction. Because of data limited, the weighted average of increasing price index is 3.96% from Zheng and Mao's discovery. In addition, the data for total property area around GI is also unavailable, thus using another measurement to discover the ratio of captured land value and GI's cost in unit area. If the result is more than 1, this service will be thought profitable. Ratio calculation can reduce the error caused by limited data resource. The formula can be created as followed:

$$RV_{Lx} = \frac{3.96\%Px \div (1+3.96\%)}{Cx}$$

RV_{Lx} means the ratio of GI's captured land value and their cost. P_x means current land price in different districts shown in table 3.2.4, and C_x means GI cost for construction and maintenance.

District	Current Land value (¥/m²)	District	Current Land value (¥/m²)
Huangpu	90672	Minhang	52664
Jing'an	91368	Baoshan	46825
Xuhui	80084	Songjiang	34493
Changning	72073	Jiading	36055
Yangpu	65245	Qingpu	31911
Hongkou	63222	Fengxian	24395
Putuo	61723	Jinshan	18840
Pudong New District	58028	Congming Island	16523

Table 3.2.4 Current Land Price (Sohu, 2019)

The third stage in this research is to use qualitative method to analysis whether the lessons from international case study can still be feasible in Shanghai to solve current barrier for government valuing GI. The analysis targets are Green bonds and equality, GI adoption and

naming, establishing social associations, encouraging vertical GI. In addition, the feasibility analysis aims at revealing Shanghai's deficiencies leading to feasibility challenges and discovering potential answers to support GI. The analysis will focus on following area:

People's willingness to support this activity (Through questionnaire);

Potential mechanism or media to support this activity (Through questionnaire and local and national documents);

Relative policy to encourage and manage this activity (Through current Shanghai GI policy 'Regulations of Green Infrastructure in Shanghai municipality').

The final stage is to test whether the theoretical calculation and solutions in stage 2 can be accepted by the government's decision makers during implementation, which can also be a good way for deliver GI's value to the government. As Chinese government do not open a large amount of data and information to the public due to state secrets, some strategies may be feasible theoretically while still difficult for the officials. This stage aims at improving the calculation and solutions to become more feasible in actual situation and will be implemented through the anonymous questionnaires with 10 planners who work in government's planning professional panel and academic authorities. They usually become important actors in government's decision-making, so that they can provide feasibility and challenges according to their actual working life under the premises of not revealing state secrets. The outcomes of the test will be followed in each topic in chapter 4.

3.3 Ethics Statement

- The interviews will not disclose interviewees' any personal information unless the interviewees agree;
- Dispose all records of interviewees after the research is completed;
- Interviews involving trade and national secret will not be asked and recorded;
- All the data used in this research is the secondary data opened for the public;
- All Chinese academic resources are translated into English accurately.

Chapter 4 The Result of GI Service Value in Shanghai

District	Fundamental Cost for GI (10^8¥)	Notes	District	Fundamental cost for GI (10^8¥)	Notes
Huangpu	6.59	Urban	Minhang	207.39	Suburban
Jing'an	18.17	Urban	Baoshan	162.28	Suburban
Xuhui	31.43	Urban	Songjiang	310.85	Outer Suburban
Changning	26.09	Urban	Jiading	189.01	Outer Suburban
Yangpu	34.17	Urban	Qingpu	252.38	Outer Suburban
Hongkou	10.02	Urban	Fengxian	242.75	Outer Suburban
Putuo	29.79	Urban	Jinshan	217.86	Outer Suburban
Pudong New District	655.77	Suburban	Chongming Island	679.04	Outer Suburban

Table 4.0 The result of GI's construction and maintenance cost

The fundamental cost for GI in different district is calculated in table 4.0, which contains the construction cost and maintenance fee in one year. GI's cost will increase merely due to maintenance cost per year in the future. This data will be compared in the following section to show whether GI service value in Shanghai is still profitable. It is not surprising that the cost for GI in suburban and outer suburban is far more expensive than urban GI because of a larger volume. This data also demonstrates extremely unbalanced GI development in Shanghai, and various cost burden to the government.

4.1 Temperature Decreasing Value

As there is no open data in district level, this section will analysis in metropolitan level. The outcome shows the government can save 562 million Yuan from avoided high temperature allowance, which is far less than the cost of GI maintenance fee. However, this saving is more expensive than most of environmental department earnings. The variable in this measure is the population, meaning districts with higher population will get more benefit from the temperature decreasing. Unfortunately, as the data limited, there is no district level data,

becoming difficult to analysis district- specific context and be added to the gross value of GI.

Area	Employees at state-owned units (Thousand)	GI's temperature decreasing value (10^8¥/year)
Shanghai Metropolitan	1418	5.62

Table 4.1.1 GI's temperature decreasing value

Government's Response

This measure becomes the most debatable among decision-makers. Figure 4.1 indicates 40% decision-makers agree with this measure, 20% stand neutrally and 40% reject the measure. The supporters thinks the 2℃ decreasing definitely reducing their two-month allowance expenditure. Meanwhile, the opponents who lives in urban area with lower GI coverage area claims some spaces with old offices buildings cannot reach 2℃ decreasing, because the GI area do not reach the proportion 6:4 with gray area. In addition, the interviewees also claims the months under 33℃ will be instable because of global warming, so that this measure can be a referable resource currently but not a long-term calculation method for GI value.

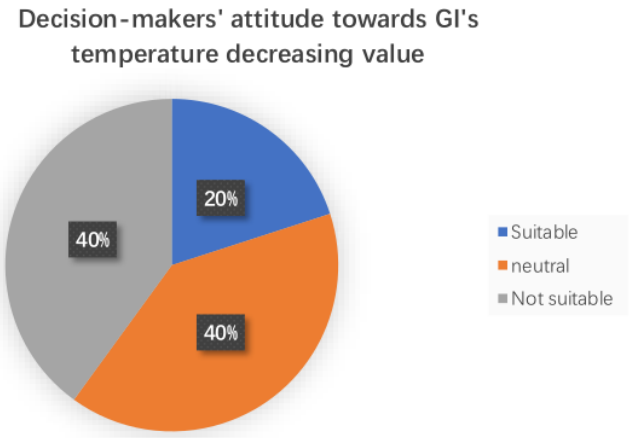


Figure 4.1 Decision makers' attitude towards GI's temperature decreasing measurement

From the responses from decision makers, the two main challenges for this measure is the

uneven development of GI and climate instability. The formula should be improved to become more district-specific and less influenced by the environment. In this term, the decision-makers give the advice to use alternative cost method and link with potential manmade temperature decreasing method- spray cooling.

The improved measure- alternative cost for spray cooling

The new measure aims at discovering what is the cost if replace current GI with spray cooling machines. From the literature review, GI with a comprehensive ecosystem in Shanghai can decrease 2℃, so that its value can be calculated as the cost for spray machine to produce equal effect. In order to demonstrate a persuasive GI's value, this measure aims at calculating the least but the most secured temperature decreasing value. It has been discovered spray machine's consumption is 43200J/m^3 for decreasing 2℃. Since GI can affect air and temperature in a higher altitude than spray machine, this measure calculates the least value by regarding the effect happening in 2D plane, so that assume spray machine's consumption is 43200J/m^2 per day and GI decrease temperature merely in its coverage area, thus 1.8kW·h for spray machine power to decrease 2℃ in 1m^2 area. According to Shanghai's temperature, it will probably be used only in July and August. Current Shanghai electricity cost is 0.5283¥/kW·h for less than 230kW·h, 0.5783 for 231-400, and 0.8283 for more than 400 per month (Overlook peak time) (FFT, 2019), the formula can be created as:

$$V_{Tx2}= 2[230 X 0.5328+170 X 0.5783+0.8283(1.8 X 10^4 S_x X 720-400)]$$

District	GI's value on Decreasing temperature (10^{10}¥/year)	Notes	District	GI's value on Decreasing temperature (10^{10}¥/year)	Notes
Huangpu	0.57	Urban	Minhang	18.01	Suburban
Jing'an	1.58	Urban	Baoshan	14.09	Suburban
Xuhui	2.73	Urban	Songjiang	26.99	Outer Suburban
Changning	2.27	Urban	Jiading	16.41	Outer Suburban
Yangpu	2.97	Urban	Qingpu	21.91	Outer Suburban
Hongkou	0.87	Urban	Fengxian	21.08	Outer Suburban

Putuo	2.59	Urban	Jinshan	18.92	Outer Suburban
Pudong New District	56.94	Suburban	Chongming Island	58.96	Outer Suburban

Table 4.1.2 GI's value on decreasing temperature by sprayer cost

The outcome shows GI's value on temperature decreasing has already excessed their cost and maintenance fee per year under conservative calculation. In addition, spray machine also has the highest performance cost ratio, so GI's temperature value can return government's cost for GI construction and maintenance within one year. Due to Shanghai's high temperature in summer, decreasing temperature becomes officials' urgent projects, especially in urban area. Although it has lower value than suburban, the larger population may lead to extra value such as allowance. Therefore, in urban area, the officials should consider using GI and its eco-system to remit heat island effect rather than any man-made facilities. Table 4.1.2 also indicates the larger area of GI will also lead to a better economic return. The largest difference even reaches 5.8 billion Yuan. Since this measure is advised and acknowledged by decision-makers, the officials in urban area should realise GI's huge value under current background and not complaining to the high construction and maintenance fee for GI. Since this value is far more than maintenance and construction cost, it is a primary service to be considered by government to pursue the best profit.

4.2 Air Improvement Value

The data in table 4.2 shows a large difference between urban and suburban area. The larger number of GI in suburban and outer suburban area leads to the advantage of air improvement value. Jiading and Qingpu are regarded as two poorest air quality districts, which are industrial districts. However, the air improvement value is both high in these two districts, so that there is less burden for these governments to maintain the environment. The most serious area is still among Shanghai urban districts. Shanghai daily air quality report shows all the urban districts are in polluted situation. The lower GI value needs officials more effort on disposing pollutants. At the same time, the lower GI disposal effect also threatens people's life. The officials can reverse this situation by enlarging the scales such as vertical GI in CBD and

discover GI with better efficiency on air improvement. Since air improvement value in all districts is less than maintenance cost, it is an additional service to deal with pollutants especially in poor air quality area and pursue neighborhood health during design.

District	Air Improvement Value (10^4¥/year)	Notes	District	Air Improvement Value (10^4¥/year)	Notes
Huangpu	7.88	Urban	Minhang	248.10	Suburban
Jing'an	21.73	Urban	Baoshan	194.18	Suburban
Xuhui	37.60	Urban	Songjiang	371.85	Outer Suburban
Changning	31.21	Urban	Jiading	226.10	Outer Suburban
Yangpu	40.87	Urban	Qingpu	301.89	Outer Suburban
Hongkou	11.98	Urban	Fengxian	290.38	Outer Suburban
Putuo	35.63	Urban	Jinshan	260.60	Outer Suburban
Pudong New District	784.45	Suburban	Chongming Island	812.28	Outer Suburban

Table 4.2 GI's air improvement value

Government's Reponses

Figure 4.2 indicates government's responses towards air improvement value calculation, with 80% agreeing this measure and 20% standing neutrally. This shows a positive feedback and means the officials acknowledge GI's air improvement value in Shanghai. There is no response of adjustment, so that GI's air improvement value can be demonstrated to the government in this way.

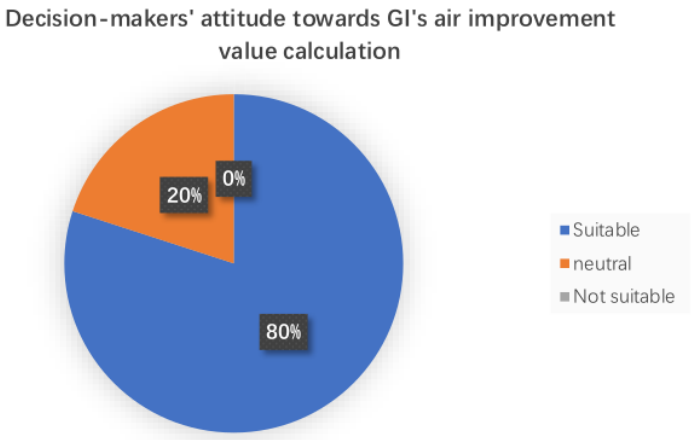


Figure 4.2 Decision makers' attitude towards GI's air improvement value measurement

4.3 Water Mitigation Value

The data from table 4.3 shows GI's water mitigation value is more significant than air improvement value. The outer suburban has the largest water mitigation than other districts due to a better interception effect and larger volume of GI. However, suburban area such as Pudong new district and Minhang district excess some outer suburban districts because of a larger volume of GI development. The value gap between urban and other districts is also increased, so that outer suburban has the most advantages towards water mitigation value. In this term, urban districts need more money for water sewage, being extremely unfriendly to Hongkou. As the second lowest value, Hongkou government will be threatened by larger scale of water sewage than urban districts due to bigger area and need more cost than other poor districts in outer suburban, whose value is 9 times more than Hongkou. Unfortunately, all urban, suburban and outers suburban's water mitigation value is less than GI's maintenance cost every year, which means this water mitigation is also an additional service to prevent flood and promote better water cycle during design.

District	Water Mitigation Value (10^4¥/year)	Notes	District	Water Mitigation Value (10^4¥/year)	Notes
Huangpu	37.07	Urban	Minhang	1254.89	Suburban
Jing'an	102.24	Urban	Baoshan	981.89	Suburban

Xuhui	176.86	Urban	**Songjiang**	1912.99	Outer Suburban
Changning	146.80	Urban	**Jiading**	1163.16	Outer Suburban
Yangpu	192.24	Urban	**Qingpu**	1553.10	Outer Suburban
Hongkou	40.53	Urban	**Fengxian**	1493.90	Outer Suburban
Putuo	167.60	Urban	**Jinshan**	1340.68	Outer Suburban
Pudong New District	3967.89	Suburban	**Chongming Island**	4178.83	Outer Suburban

Table 4.3 GI's water mitigation value

The variables contributing to the outcomes are volume of GI and GI's interception GI. The first variable leads to fact that the larger area GI covers, the better it has on water mitigation value. In addition, as the coefficient before S_x is $5.25 \times 31.42 \times 10^{-2}$ and multiple interception data (more than 843.47), which is far more than air improvement's 250, so that water mitigation value in Shanghai is larger than air improvement value and increases faster if GI's number increase. The other variable is interception effect. Going back to Yu et al. (2016)'s report, the elements leading to a better interception effect in outer suburban are the network of GI system and soil's permeability. Therefore, the strategy focusing on urban area to improve water mitigation value can be connecting different types of GI such as building green corridors and linear parks, and use soil conditioners.

Government's Response

Figure 4.3 shows the response from decision-makers, with 70% agree with this method and 30% with neutral attitude. This result shows a positive attitude from the government and there is also no feedback towards adjustment of this calculation method, so that the value of GI's water mitigation value and way of improving this value can be demonstrated to the government as mentioned above.

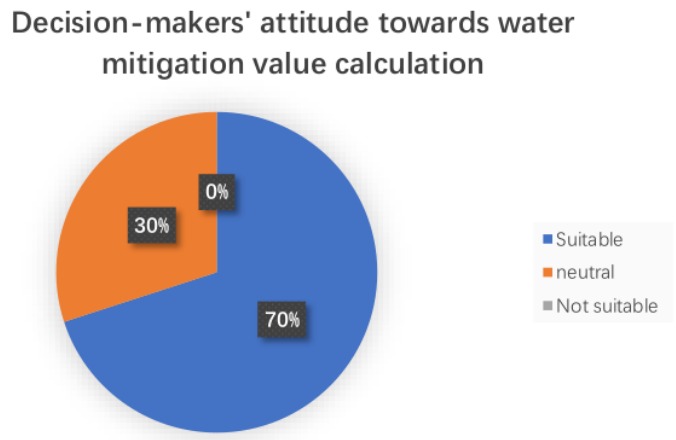


Figure 4.3 Decision-makers' attitude towards GI's water mitigation measurement

4.4 Land Value Capture

The data in table 4.4 shows all urban, suburban and outer suburban can profit from GI's land value capture. GI's land value capture in urban area becomes larger than suburban area, especially Jingan's GI value has 14 times more than GI's cost. Compared with the previous value, GI's land value capture service can benefit urban area more, so that the governments can earn much money from the property market. As the time goes on, this ratio will become larger because of increasing land price, which is the most decisive factor. Therefore, when government designs the GI, especially for urban area, the location of GI from the neighborhood is important. At the same time, the suburban government with lower ratio can also increase land value capture rates by considering the typology of properties. For example, Dunse (2007) indicates detached houses can have a larger value growing for land, which is difficult to be built in urban area. Since GI's land value capture have benefit in all Shanghai, it should be considered as a primary service during decision-making.

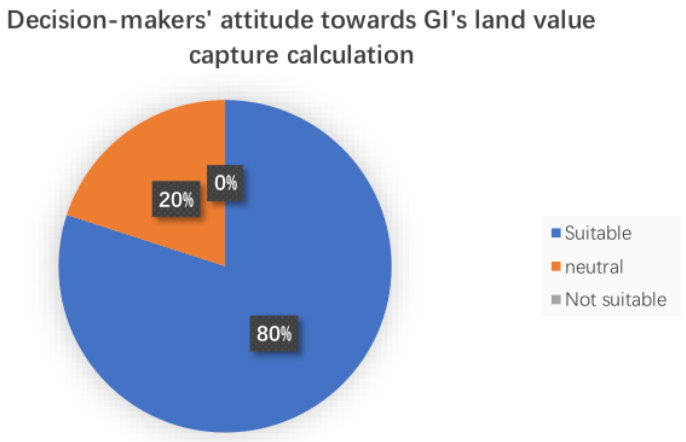
District	Ratio	Notes	District	Ratio	Notes
Huangpu	13.98	Urban	Minhang	8.11	Suburban
Jing'an	14.07	Urban	Baoshan	7.21	Suburban
Xuhui	12.33	Urban	Songjiang	5.31	Outer Suburban
Changning	11.10	Urban	Jiading	5.55	Outer Suburban

Yangpu	10.05	Urban	**Qingpu**	4.92	Outer Suburban
Hongkou	9.74	Urban	**Fengxian**	3.76	Outer Suburban
Putuo	9.51	Urban	**Jinshan**	2.90	Outer Suburban
Pudong New District	8.94	Suburban	**Congming Island**	2.55	Outer Suburban

Table 4.4 GI's land value capture profit

Government Response

Figure 4.4 shows the response from decision-makers, with 80% agree with this method and 20% with neutral attitude. This result shows a positive attitude from the government. Most decision-makers strongly support it, because it has been currently a primary GI service purpose for intervention on green economy and GI planning. 1 neutral interviewee is afraid of the accuracy of the profit. Although there is limited data for detailed housing prices, and Shanghai's land value capture model, most of the data for GI service takes a relatively lower value, so that the actual profits may only larger than the outcomes calculated. At the same time, as mentioned above, the ratio method can also help to decrease the error.



Decision-makers attitude towards GI's land value capture measurement

Chapter 5 Feasibility of Potential Methods to Eliminate Barriers to Valuing GI

Although GI services value is demonstrated profitable in Shanghai, there are two main barriers for government to valuing GI- limited fund and land, as mentioned in literature review section. This section will analysis the feasibility of lessons from international case study which dealt with the similar challenges. If the barrier removed, Shanghai's green economy and GI development will be sustainable with the emphasis on valuing GI. For the willingness response analysis, good is 2 scores, little is 1 score and no is 0 score.

5.1 Green Bonds and Green Equities

The outcome of people's willingness towards green bonds and green equities is shown in figure 5.1. The average score for this method is 1.33, which shows a large proportion of people favour this method. Some of the supporters mentioned Shanghai has GI projects towards energy conservation in building. The document 'Measures for support of building energy conservation projects in Shanghai municipality' mentions the government will compensate ¥60/m^2 for the model projects (SHG, 2010). However, the opponents also regard projects towards GI maintenance and construction as a public benefit projects rather than profitable projects, According to GI's water mitigation and air improvement service mentioned in section 4, merely focusing on these two services may not be profitable while more risk of loss. Therefore, green bonds and green equities may not be profitable unless the government set extra incentives and boost green economy chain. However, the questionnaires show people still have large expectation on green bonds and green equities. They think this method have the potential to become profitable as building and energy projects are still heated in Shanghai. The value of green bonds and equities can be added from other income from the buildings.

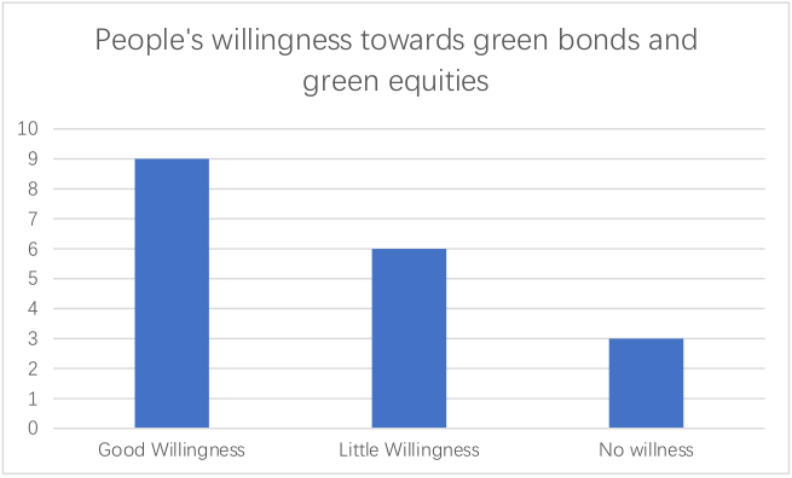


Figure 5.1 People's willingness to green bonds and green equities

The primary reason for both officials and public's hesitation for GI projects is lack of awareness of GI's service value. According to section 4, GI's service value can be profitable when connecting with land value capture and temperature decreasing. This theory is difficult to be delivered to the society if the government do not pay an attention to it. Although policy 3 in SHGIR mentions 'the local government should integrate GI development into social economy development' (SCOPC, 2007), few criteria and regulation is set this policy, so that it makes this policy more indicative rather than statutory. The government should follow this policy by delivering GI's service value to the society. At the same time, the officials themselves should also understand maintaining GI is not merely a public- beneficial projects. As GI service can boost local economy, especially increasing property value, this value can be considered being added to green bonds and equities.

Shanghai, as the economic centre in China, has the largest trading volume, and have one of the two stock exchanges in Chinese mainland called Shanghai Stock Exchange (SSE). It was approved by People's Bank of China and opened in 1990 (SSE, 2018). SSE can provide venues and facilities for securities trading, formulates the business rules of the stock exchange, organise and monitor stock exchange, regulate memberships and listed companies, and manage and publish market information (SSE, 2018), which is similar with Singapore Exchange's effect. In addition, SSE is directly regulated by China Securities Regulatory

Commission, forming a comprehensive implementation and regulation mechanism for exchanges. Therefore, besides a large population base, green bonds and equities have better opportunities to develop than other regions. However, SSE cannot have the same effect on leading green bonds and equities exchange currently as Singapore Exchange, because green economy in Shanghai is not as developed as Singapore. The government's role is to encourage this phenomenon in SSE and promote this idea together with GI service value. This can both attracting fund for GI development, and incentive local green economy.

Unfortunately, SHGIR document does not have any policy support this idea. Although SHGIR clarifies the secondary government should be responsible for GI development, the way for getting fund is extremely sole in this document, which is difficult to form a green economy circle. In addition, if green bonds and equities are implemented, more specific policies towards regulation and implementation of green bonds and equities should be raised instead of obeying common exchange law set by SSE. On the positive site, SHGRI contributes to a transparent and fair market. Policy 38 mentions local GI management apartment should establish GI information system, publish GI management, construction and maintenance information and monitor GI resource (SCOPC, 2007). Policy 39 also mentions government's fund towards GI is monitored by fiscal and audit department (SCOPC, 2007). It means the information of GI projects are opened to the public, so that people can decide whether to invest in according to this information. At the same time, third-party supervision decreases the risk of corruption, which provides investor a safe environment. Therefore, the policy in Shanghai support the potential safety and order for green bonds and equities.

The outcome and analysis show green bonds and equities have a good potential to be implemented in Shanghai. It has comparatively large supporters, potential mechanism from SSE, and policy to regulate the potentially safe market. However, the barrier for governments' valuing GI is also delivered to the public, as people may overlook GI service value. Indeed, this method now is strongly based on governments' recognition of GI value. The governments' role is to relate green bonds and equities with GI's primary service's value to make them

profitable. At the same time, relative policy towards a variety way of getting fund should be set, with specific green bonds and equities regulation. Therefore, it can set indicative and statutory work for secondary government to solve GI unbalanced situation.

5.2 Green Adoption and Naming

The outcome of the questionnaire shows 16 people with good willingness and 2 with little willingness to this method. The average score is 1.89, showing a great willingness. Among the 18 questionnaires, there is no critique towards this method. One kind of people support for the hobby for relaxing in the busy Shanghai and contributing to a better environment. The other people support for a better reputation, which provides a brighter future. In fact, although most people do not realise the GI's service value, they do notice the importance of GI to the environment. Therefore, they are eager to adopt single tree which is not expensive and the naming can also give them a sense of satisfactory.

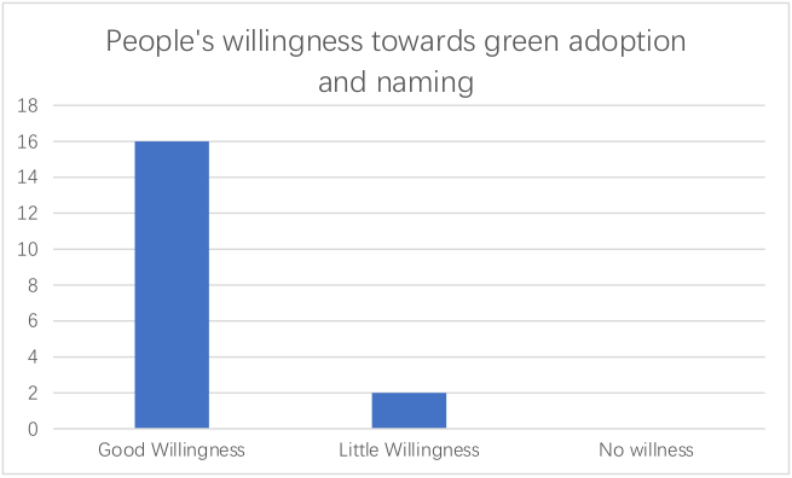


Figure 5.2 People's willingness to green adoption and naming

The advantage of green adoption in Shanghai is that some authorities holds the activities of planting trees and GI adoption around Chinese Arbor Day every year. Individual or companies who want to adopt certain GI can submit their profile to Landscaping Bureau and other relative authorities. Shanghai Botanical Garden has already put forward this method that the GI adoption fee is ¥50/m^2 for two years (SBG, 2017). At the same time, SBG also mention individual or companies who adopts the GI can hang unified production of the adoption sign

on the tree and get adoption certification (SBG, 2017). This is regarded as a comprehensive adoption mechanism which can be referred by secondary government. Another potential way of adopting and naming trees is through online system called Ant Forest. Currently, Ant Forest has been operated through Alipay client for public benefit. If users decrease carbon emission by using this app, they can plant a virtual trees in this app. After the virtual tree grows up, public-welfare organisations and environmental protection enterprises will plant actual trees named by users (Youyu, 2019). In this term, Ant Forest can also be potentially used for existing GI's adoption and naming. For example, users who have done great effort to sustainable environment have the right of adopting GI and naming it in 2 years. The information of numbers and types can be provided by the governments according to their current finance situation.

Green adoption and naming are highly encouraged and put forward in SHGIR. Policy 5 encourages individual and companies to adopt GI and have the right to name them (SCOPC, 2007). People or companies who provides great efforts to GI maintenance will also be certified and praised by local authorities (SCOPC, 2007). In addition, during the adoption work, the criteria of maintenance are set in 'Garden and green space daily maintenance and management standard in Shanghai' to ensure the quality of adoption work, which is monitored by GI management department.

Since it has strong supporters, suitable media and mechanism and enough policies to support green adoption and naming, it becomes easier to be implemented by government further from SBG case to decrease the burden on GI maintenance. Nowadays, governments' role is to promote this method to the society through online or posters near GI to attract more people.

5.3 Encouraging Social Association for GI Autonomy

The questionnaire shows 3 people with good willingness, 6 people with little willingness and 9 people with no willingness to this method. The average score is 0.67, a disappointing score. Unsurprisingly, the most supporters are the group of elder and people who have less pressure on earning money in Shanghai. Except the opponents interviewed by questionnaire, a large

number of people in Shanghai complain the pressure on survive in the metropolitan and they do not want to spend extra money and energy on social association to protect local GI. This phenomenon indicates public awareness towards GI is far less than western countries, so that self-organising social association to manage GI is nearly impossible currently. The interviewees' response shows most people cannot realise their daily reliance on GI and profit got from GI. The way of reversing this problem should start from improving people's awareness and government interventions' on organising social association.

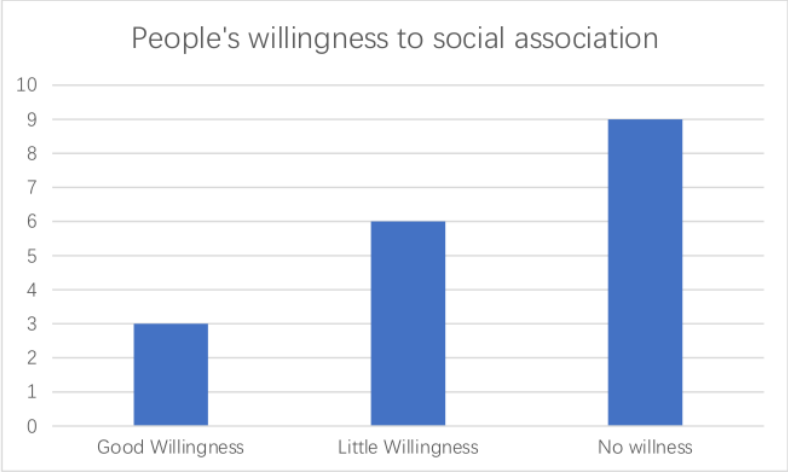


Figure 5.4 People's willingness to social association

The reason leading to the problems is few government's action towards GI publicity and association funding and limited policies to indicate or control social participation. SHGIR policy 5 mentions the local government has the duty on organising and promoting social participation in GI management by investment, donation and adoption (SCOPC, 2007). The investment and adoption work have the potential chance as analysed in last two sections, while this kind of social organisations regarded as non-profitable have no chance to survival unless people's awareness is improved. The experience from developed countries shows two important elements for good awareness- one way is government's promotion in the society. Currently, though SHGIR put forward social participation, no criteria and indicative work is set in any document. In addition, both government's website and social media have limited column to report GI-related topic nowadays, so that less people may care about what GI actually happens in Shanghai. The other method is to improve GI education in school. Unfortunately,

neither local policies nor courses in schools focus on GI education.

One difficulty in mechanism of social association operation is lack of institution for liability and monitoring. Since there has been no relative policies and laws towards management of social association, associations are difficult to run in a long-term due to lack of fund to maintain GI. Government need to set the criteria and regulations on how to help social associations. Additionally, no liability and monitoring institution also leads to the problem as Professor Li mentioned that the group without profession to maintain GI may lead to damage of GI, which increases the management cost. Although Shanghai has 'Garden and green space daily maintenance and management standard', there is few authorities willing to responsible for the liability of non-profit and unprofessional social association.

Currently, no incentive policies and systems also make social organisation an absolutely non-profit team, which does not conform to current Shanghai background of earning as much as you can. Therefore, because of low GI awareness, lacking mechanism and policy to support, non-profit social organisation cannot survive under Shanghai's background in a short term, so that GI autonomy is difficult to achieve. Meanwhile, officials have already thought about created different actors to manage GI to decrease governments' pressure and conflict with society. For example, policy 23.2 states GI in residential area are managed by local property management department (SCOPC, 2007), which is constituted of both property owners and local professional maintainers. It is good way of raising property owners' awareness of GI. At the same time, policy 5 and 7 in SHGIR reward donation and people leading public benefit with certification, which can also relate to personal credit system in future. If social awareness is developed, people will probably form an organisation to protect their environment. The organisation's fund will come from more various ways such as membership and property management fees (China now already had, but no relationship with GI management, as residents don't want to pay). At the same time, the government also need to target on the right group such as with less pressure on living and fund or bonus these organisations to let them operate.

5.4 Encouraging Vertical GI

This section is different from previous 3 sections, because vertical GI has another effect on dealing with land restriction problem in Shanghai. The outcome in figure 5.4 shows 14 people with good willingness and 4 people with little willingness. The average score 1.78, which shows a perfect social reflection. As mentioned in the literature review, Shanghai's GI development is quite uneven. People living in busy district are eager to improve current 'gray' grid, so that the supporters think vertical GI will not occupy limited land and improve the urban environment as well as indoor environment. Fortunately, many people have realised the profit of vertical GI. It has been estimated 35 private enterprises and 19 state-owned enterprises had vertical GI business in Shanghai in 2015 (SLCAAB and SFB, 2015), which shows a strong official and social attention.

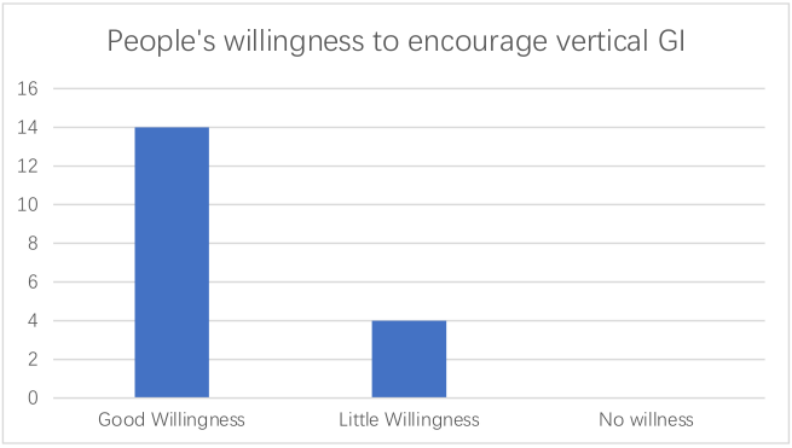


Figure 5.4 People's willingness to vertical GI

Shanghai's vertical GI development is optimistic due to a good policy and mechanism basis. SHGIR policy 23.4 states vertical GI is managed by the owners of buildings or structures SCOPC, 2007), which means governments will save a large amount of money. It can both saves the land restriction problems and governments' financial problems. Therefore, the governments have paid a lot attention on this method. In 2017, Shanghai's government firstly list vertical GI subsidy into 'The 13th five-year plan for city greening' that general vertical GI project will be compensated ¥50/m^2 and complex roof garden will be compensated ¥200/m^2(SHG, 2016). However, this is not enough because the cost of vertical GI is from ¥50/m^2 to ¥3000/m^2 (SHG, 2019), which decreases some companies' willingness to invest in

or construct vertical GI. This leads to lacking investment in the market. The government needs to adjust incentive policy to attract investment back to vertical GI market. Besides self-managed vertical GI, the government also claims another pattern that construction owners and local GI department manage GI together. This can reduce owners' pressure on vertical GI construction and maintenance. For vertical GI, Shanghai has a comprehensive mechanism of market competition- bidding, as mentioned in literature review. The transparent and fair competition environment may attract more investors and boom Shanghai's green economy.

SHGIR is quite lag towards vertical green because it merely points out the general regulation without a clear criteria and mechanism, so that vertical GI planning in Shanghai is not comprehensive and overlooks urban design due to the lack of policy basis. This causes monotonous designing which decreases aesthetic effect. Document 'The 13th five-year plan for city greening' then set the criteria the area of vertical GI should more than 20% total building area (SHG, 2016), and it also points out the responsibility as discussed in last paragraph. Therefore, together with last paragraph, the policy towards vertical green in Shanghai has a clear objective and compensation, but still need design-based criteria to make it rich. Without a suitable design coordination, the cost will increase by property damage and decreased GI services.

Strong willingness, adequate mechanism and policies make vertical GI a good prospect to develop. It becomes the most potential method to solve land restriction problems in Shanghai old districts and alleviate governments' financial problem at the same time. The population, economy situation and eco-city catchword also give a hand to vertical GI development. However, the most serious challenge now is the lacking investment in vertical GI market. The government should improve intervention such as compensation increased to incentive local market again. The government need to discover and cultivate the leading enterprise in Shanghai. At the same time, the policy should also be complemented to indicate vertical GI's design about how to coordinates with different types of buildings and which type of vertical green is promoted or prohibited.

Chapter 6 Conclusion and Prospect

The outcome of the research shows GI in Shanghai, like most global metropolitan is valuable. Therefore, the construction and maintenance of GI is not a financial burden to the government. On the contrary, it can bloom the local economy if the government maxmises its service and establish relevant policy and mechanism to support. GI has the most profitable value in decreasing temperature and land value capture to the government. It means when decision-makers prepares GI planning, these two services should be considered at first. Especially in urban area, the larger number of people and more expensive land give GI value more potential to be enlarged than suburban area. Although water mitigation and air improvement value are less than maintenance cost, they cannot be overlooked as they are important elements for urban system and public health. Besides increasing the volume of GI, the government can also increase GI's value by improving GI's variety, soil quality, promoting comprehensive eco-system and choosing intensive and busy location, which are the elements to decide variables during calculation. However, the data for Shanghai is extremely limited. Other services probably relating to government's finance such as insurance value cannot be calculated. Current calculation is also based on weighted average and conservative method. Hopefully, there will be another research to calculate every value accurately by official who has availability for secreted data.

Funding shortage and land restriction are regarded as two main challenges for the government to value GI, which also leads to uneven development of GI in Shanghai. In order to let official accept the value measurement discussed in chapter 4, this article also inspires from Singapore, American, German, Korean and Japanese case study and attempts to use their solutions to solve Shanghai's challenges. Green bonds and equities, adoption and naming, and vertical green have a good social reflection and good mechanism to support. However, except adoption and naming, all methods lack policy to regulate. In addition, the difficulty of social association method also reflects current policy's flaw. Currently, SHGIR does not produce a variety of fund sources, so that regulation and criteria for green economy is less pointed out in the document. Therefore, the government should realise GI's value at first and give

interventions on these potential ways for decreasing burden. If government can use GI's service value, green economy will have virtuous circle. At the same time, SHGIR should provide a variety of fund resources by using GI service value towards the society, and set intervention criteria and mechanism to create statutory basis. Another difficulty happening in all methods is the low awareness of GI value among people. Because of no criteria and regulation in the policy, GI publicity is an indicative work rather than statutory one. SHGIR should set index to force officials to promote GI's value to the society and take it to the assessment.

Shanghai will have a prosperous green economy if officials and residents' awareness of GI increase, as GI can truly bring capital value to the government. This article is the first research to demonstrate Shanghai's GI value, hope there will be more comprehensive researches towards GI value in the future, because it will reflect increasing attention towards GI development and people's living environment.

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Appendix A Questionnaire

Questionnaire for decision-makers

Hello, my name is Junxian from University College London. I'm doing my dissertation about Shanghai's GI service value. May I ask you some questions about your consideration?

1. Do you want me to provide your name in the dissertation?

A. Yes B. No

2. GI can decrease high temperature in summer. Is that suitable to use 'avoidance cost method' to calculate the decreasing amount of high temperature allowance from government to represent GI's decreasing temperature value?

A. Suitable B. Neutral C. Unsuitable

Reason:

3. GI can improve surface water circle in rainy day. Is that suitable to use 'alternative cost method' to calculate governments' extra cost for water mitigation without GI to represent GI's water mitigation value?

A.Suitable B. Neutral C. Unsuitable

Reason:

4. GI can improve air quality. Is that suitable to use 'avoidance cost method' to calculate government's cost for disposing pollutants SO_2 and NO_x to represent GI's air improvement value?

A.Suitable B. Neutral C. Unsuitable

Reason:

5. GI can increase land property's price. Is that suitable to use 'hedonic method' to calculate the amount of increased land price due to GI to represent GI's land value capture service?

A.Suitable B. Neutral C. Unsuitable

Reason:

6. Do you have any other advices or polices suggestion for other GI service value?

Questionnaire for general people

Hello, my name is Junxian from University College London. I'm doing my dissertation about Shanghai's GI service. I have found some international cases to solve current government's challenges. May I ask you some questions about your willingness towards these projects?

1. Do you want me to provide your name in the dissertation?

A. Yes B. No

2. Encourage social participation and the society can establish a non-profitable organisation to responsible for local GI. The fund come from membership fees, social donation and property management fee.

A. Good Willingness B. Little Willingness C. No Willingness

Reason

3. Promote green bonds and green equities

A. Good Willingness B. Little Willingness C. No Willingness

Reason

4. Promote green adoption and naming

A. Good Willingness B. Little Willingness C. No Willingness

Reason

5. The government give compensation to vertical green in CBD area to solve land restriction problems

A. Good Willingness B. Little Willingness C. No Willingness

Reason

6. Do you have any other interested projects?

Appendix B Risk Assessment Form

RISK ASSESSMENT FORM

FIELD / LOCATION WORK

The Approved Code of Practice - Management of Fieldwork should be referred to when completing this form

http://www.ucl.ac.uk/estates/safetynet/guidance/fieldwork/acop.pdf

DEPARTMENT/SECTION: BARTLETT SCHOOL OF PLANNING/ INTERNATIONAL PLANNING

LOCATION(S): 14 UPPER WOBURN PLACE, LONDON, WC1H 0NN

PERSONS COVERED BY THE RISK ASSESSMENT: Yes

BRIEF DESCRIPTION OF FIELDWORK:

A site visit to my home city-Shanghai to analysis the current and future situation.

Consider, in turn, each hazard (white on black). If **NO** hazard exists select **NO** and move to next hazard section. If a hazard does exist select **YES** and assess the risks that could arise from that hazard in the risk assessment box.

Where risks are identified that are not adequately controlled they must be brought to the attention of your Departmental Management who should put temporary control measures in place or stop the work. Detail such risks in the final section.

ENVIRONMENT	**The environment always represents a safety hazard. Use space below to identify and assess any risks associated with this hazard**
e.g. location, climate, terrain, neighbourhood, in outside organizations, pollution, animals.	Examples of risk: adverse weather, illness, hypothermia, assault, getting lost. Is the risk high / medium / low ? Low

CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**
☐	work abroad incorporates Foreign Office advice
√	participants have been trained and given all necessary information
☐	only accredited centres are used for rural field work
☐	participants will wear appropriate clothing and footwear for the specified environment
☐	trained leaders accompany the trip
☐	refuge is available
☐	work in outside organisations is subject to their having satisfactory H&S procedures in place
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

EMERGENCIES	Where emergencies may arise use space below to identify and assess any risks
e.g. fire, accidents	Examples of risk: loss of property, loss of life

No

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk

☐	participants have registered with LOCATE at http://www.fco.gov.uk/en/travel-and-living-abroad/
☐	fire fighting equipment is carried on the trip and participants know how to use it
☐	contact numbers for emergency services are known to all participants
☐	participants have means of contacting emergency services
☐	participants have been trained and given all necessary information
☐	a plan for rescue has been formulated, all parties understand the procedure
☐	the plan for rescue /emergency has a reciprocal element
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

EQUIPMENT	Is equipment used?	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. clothing, outboard motors.	Examples of risk: inappropriate, failure, insufficient training to use or repair, injury. Is the risk high / medium / low ?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk

☐	the departmental written Arrangement for equipment is followed
☐	participants have been provided with any necessary equipment appropriate for the work
☐	all equipment has been inspected, before issue, by a competent person
☐	all users have been advised of correct use
☐	special equipment is only issued to persons trained in its use by a competent person
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

LONE WORKING	Is lone working a possibility?	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. alone or in isolation lone interviews.	Examples of risk: difficult to summon help. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangement for lone/out of hours working for field work is followed
☐	lone or isolated working is not allowed
☐	location, route and expected time of return of lone workers is logged daily before work commences
☐	all workers have the means of raising an alarm in the event of an emergency, e.g. phone, flare, whistle
☐	all workers are fully familiar with emergency procedures
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

ILL HEALTH	**The possibility of ill health always represents a safety hazard. Use space below to identify and assess any risks associated with this Hazard.**
e.g. accident, illness, personal attack, special personal considerations or vulnerabilities.	Examples of risk: injury, asthma, allergies. Is the risk high / medium / low? Low

CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**
☐	an appropriate number of trained first-aiders and first aid kits are present on the field trip
√	all participants have had the necessary inoculations/ carry appropriate prophylactics
☐	participants have been advised of the physical demands of the trip and are deemed to be physically suited
☐	participants have been adequate advice on harmful plants, animals and substances they may encounter
☐	participants who require medication have advised the leader of this and carry sufficient medication for their needs
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

TRANSPORT	**Will transport be required**	**NO**		**Move to next hazard**
		YES	√	**Use space below to identify and assess any risks**
e.g. hired vehicles	Examples of risk: accidents arising from lack of maintenance, suitability or training Is the risk high / medium / low? Low			

CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**
√ ☐	only public transport will be used
☐	the vehicle will be hired from a reputable supplier
☐	transport must be properly maintained in compliance with relevant national regulations
☐	drivers comply with UCL Policy on Drivers http://www.ucl.ac.uk/hr/docs/college_drivers.php

☐	drivers have been trained and hold the appropriate licence
☐	there will be more than one driver to prevent driver/operator fatigue, and there will be adequate rest periods
☐	sufficient spare parts carried to meet foreseeable emergencies
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

DEALING WITH THE PUBLIC	**Will people be dealing with public**	YES	**If 'No' move to next hazard** **If 'Yes' use space below to identify and assess any risks**
e.g. interviews, observing	Examples of risk: personal attack, causing offence, being misinterpreted. Is the risk high / medium / low? Low		

CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**
☐	all participants are trained in interviewing techniques
☐	interviews are contracted out to a third party
☐ √	advice and support from local groups has been sought
☐ √	participants do not wear clothes that might cause offence or attract unwanted attention
☐ √	interviews are conducted at neutral locations or where neither party could be at risk
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

WORKING ON OR NEAR WATER	**Will people work on or near water?**	**NO**	**If 'No' move to next hazard** **If 'Yes' use space below to identify and assess any risks**
e.g. rivers, marshland, sea.	Examples of risk: drowning, malaria, hepatitis A, parasites. Is the risk high / medium / low?		

CONTROL	**Indicate which procedures are in place to control the identified risk**

MEASURES	
☐	lone working on or near water will not be allowed
☐	coastguard information is understood; all work takes place outside those times when tides could prove a threat
☐	all participants are competent swimmers
☐	participants always wear adequate protective equipment, e.g. buoyancy aids, wellingtons
☐	boat is operated by a competent person
☐	all boats are equipped with an alternative means of propulsion e.g. oars
☐	participants have received any appropriate inoculations
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

MANUAL HANDLING (MH)	Do MH activities take place?	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. lifting, carrying, moving large or heavy equipment, physical unsuitability for the task.	Examples of risk: strain, cuts, broken bones. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangement for MH is followed
☐	the supervisor has attended a MH risk assessment course
☐	all tasks are within reasonable limits, persons physically unsuited to the MH task are prohibited from such activities
☐	all persons performing MH tasks are adequately trained
☐	equipment components will be assembled on site
☐	any MH task outside the competence of staff will be done by contractors
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

SUBSTANCES	Will participants work with substances	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. plants, chemical, biohazard, waste	Examples of risk: ill health - poisoning, infection, illness, burns, cuts. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk

- ☐ the departmental written Arrangements for dealing with hazardous substances and waste are followed
- ☐ all participants are given information, training and protective equipment for hazardous substances they may encounter
- ☐ participants who have allergies have advised the leader of this and carry sufficient medication for their needs
- ☐ waste is disposed of in a responsible manner
- ☐ suitable containers are provided for hazardous waste
- ☐ OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

OTHER HAZARDS	Have you identified any other hazards?	NO	If 'No' move to next section If 'Yes' use space below to identify and assess any risks
i.e. any other hazards must be noted and assessed here.	Hazard: Risk: is the risk		

CONTROL MEASURES	Give details of control measures in place to control the identified risks

Have you identified any risks that are not adequately controlled?			
	NO	√	Move to Declaration
	YES	☐	Use space below to identify the risk and what action was taken

Is this project subject to the UCL requirements on the ethics of Non-NHS Human Research?	No
If yes, please state your Project ID Number	

For more information, please refer to: http://ethics.grad.ucl.ac.uk/

DECLARATION

The work will be reassessed whenever there is a significant change and at least annually. Those participating in the work have read the assessment.

Select the appropriate statement:

√	I the undersigned have assessed the activity and associated risks and declare that there is no significant residual risk
√	I the undersigned have assessed the activity and associated risks and declare that the risk will be controlled by the method(s) listed above

NAME OF SUPERVISOR

**** SUPERVISOR APPROVAL TO BE CONFIRMED VIA E-MAIL ****