Residents' Perception of Urban Forestry in Macao

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ABSTRACT

Macao's infrastructure development has not yet caught up with its rapid economic growth, resulting in many environmental problems. Urban forestry concepts and practices can be used to make environmental improvements in Macao, and public participation can be useful in the planning processes. This project focused on understanding residents' perceptions of urban greening practices in Macao. I surveyed Macao residents using surveys, focusing on the perception of current greening practices, plant choice preferences, and proposed strategies for existing and future greening methods. The results showed that respondents were slightly dissatisfied with the current greening practices, and requested more trees and green spaces. Most survey participants preferred additional vegetation in parks and streets, in which evergreen trees, flowering plants, and the round-headed tree shape were most preferred for both sites. The majority of respondents disliked flower pots on ground because they block sidewalks and collect rubbish. Respondents suggested eliminating flower pots and switching to other greening methods. Many respondents suggested planting wind-resistant trees and tree species that can absorb air pollutants in streets. Some respondents recommended using rooftop gardens and green corridors to connect discrete green patches in the Macao peninsula. Based on my survey results, I suggested planting more trees in parks and in wide streets, introducing vertical greening into densely populated areas of the Macao peninsula, and frequent maintenance and cleaning of all green spaces in Macao.

KEYWORDS

Urban green space, greening methods, citizen participation, city planning, sustainable design

INTRODUCTION

Macao, officially known as the Macao Special Administrative Region (Macao SAR), is located next to Hong Kong in southern China, at the mouth of the Pearl River Delta. Macao SAR consists of the Macao peninsula, Taipa Island, Coloane Island, and the Cotai reclamation area, which links the Taipa and Coloane islands (Fig. 1) (Government Information Bureau 2011).

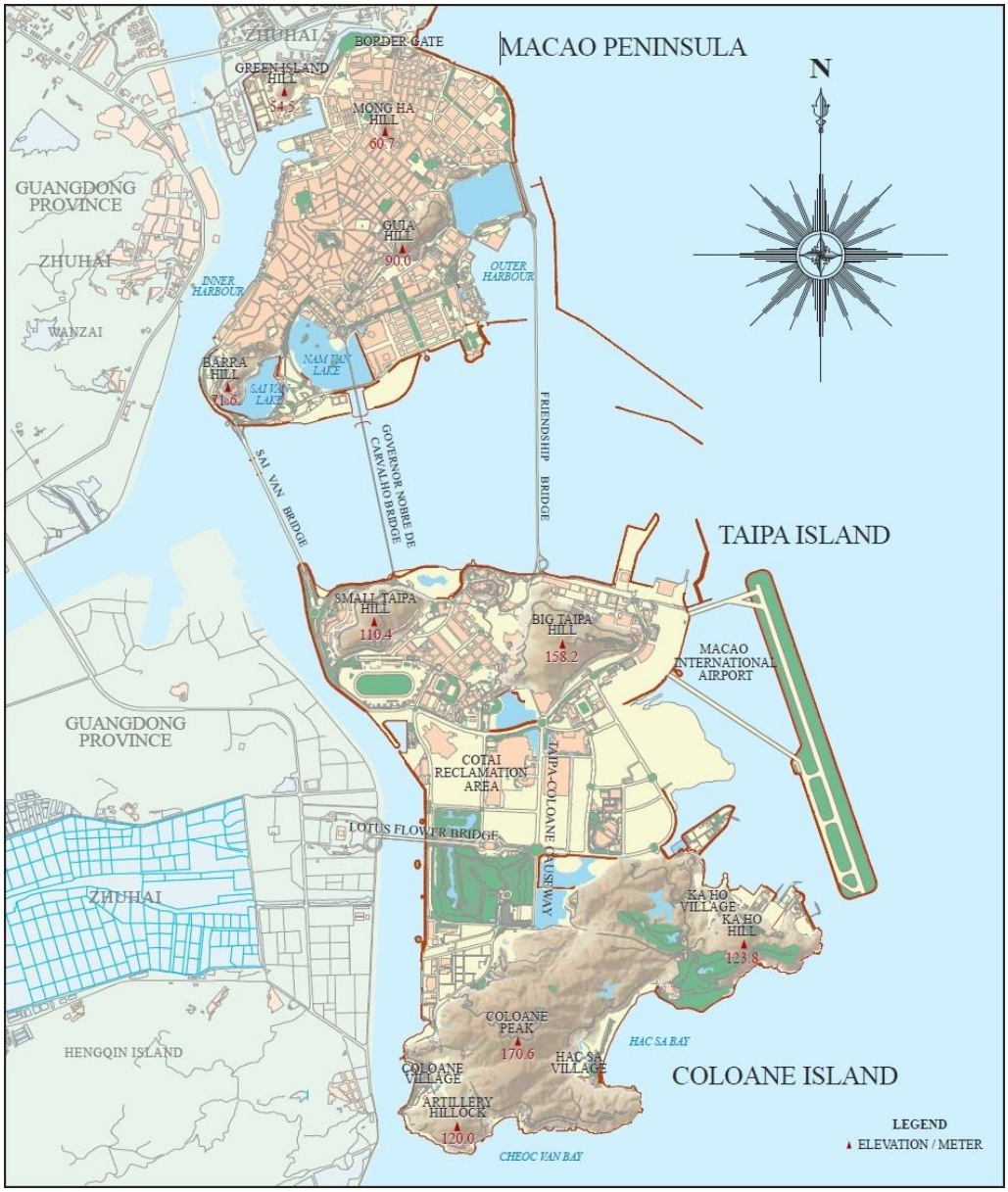

Fig. 1. Full map of Macao. This map is from Macao Yearbook 2011.

Macao has the potential to become well-known for its historical buildings and recreational opportunities because of World Heritage and Portuguese architectural influence. Macao has a five-hundred-year history of Portuguese settlement, leaving the city with a lot of treasures, such as beautiful European styled and mixed Chinese-European styled buildings, the UNESCO World Heritage, the Portuguese name "Macau", and the long and interesting street names. Since the Portuguese government allowed gambling industry in Macao in the late nineteenth century, many people come to Macao for gambling and fun. Thus Macao is currently recognized internationally primarily for its gambling sites. Macao is generally not recognized for being a green city or having recreational potential because it lacks several qualities associated with livability and sustainability such as urban forests, landscape management, and a sustainable energy strategy (Chen et al. 2008, Jansson and Lindgren 2012, Sadownik and Jaccard 2001). Macao's infrastructure development has not caught up with its rapid economic growth over the past few decades, and the city has many social and environmental problems (Pannell 2008, Zhu and Pinheiro 2010). Narrow streets, uneven development of commercial and residential buildings, shortage of public transportation, poor air quality, inadequate solid waste disposal and other environmental problems characterize the city (Yu 2008, Zhu and Pinheiro 2010).

The Macao government has improved the situation in recent years (Environmental Protection Bureau (EPB) 2009, EPB 2010). For example, the government has renewed the World Heritage site and surrounding buildings, improved signage for tourists, and renewed the bus systems over the past decade (EPB 2000, EPB 2010). With the rapid expansion of the city, Macao needs to continue improving energy and environmental management to become more sustainable. In addition to these recent citywide changes, the government can improve urban landscape management. For example, developing and maintaining urban forests could make the "concrete city" green for both citizens and tourists to enjoy the recreational and historical aspects of Macao (Jansson and Lindgren 2012).

Urban forestry concepts and practices can be used to minimize impacts of rapid development on the surrounding environment and providing an economically, socially, and environmentally sustainable place for living (Jansson and Lindgren 2012). Increased tree canopy and other urban forestry practices can provide many microclimate and environmental quality benefits for cities, such as reducing air pollution and urban heat island effects (Bowler et al. 2010, Leung et al. 2011). In addition, urban green spaces can also provide social and cultural

opportunities, like recreation, visual amenity, and cultural heritage value (Jim and Chen 2006, Jim and Chen 2009). However, urban forestry and sustainable development are not always the priority for a rapidly growing city (Yu 2008). Rapid development in a compact city often reduces the amount of green space (Jim 1998), which can present challenges when implementing urban forestry practices.

The Macao Environmental Protection Bureau (EPB) has been increasing and developing the urban green space in Macao (EPB 2010). Since 2000, EPB has planted more trees on street sides, introduced vertical greening and roof top gardens, and created an ecological zone in Cotai, which is a wetland preserved for bird foraging area and habitat (EPB 2004, EPB 2009, EPB 2010). When the Bureau develops a new area in Taipa or Cotai, they plan wide roads with trees to provide more green space. When renewing narrow old streets in Macao peninsula, they added vertical fences with vines to green the "concrete city". Although the government has been striving to green Macao, local communities are seldom involved in environmental planning processes, in which residents' perceptions may be helpful and important (EPB 2006, EPB 2007, EPB 2009, Yu 2008).

For urban forestry programs to be successful, city residents' opinions regarding greening methods and planting locations can be important because residents have knowledge of daily experiences in and around their living space. Every day residents walk through streets and notice every detail happening around the areas; while the governors and other officials only visit occasionally and may not notice the needs and problems. Thus residents' ideas and opinions may help the environmental planning processes by providing suggestions on potential greening methods, plant species choice and siting, and possible solutions to the current problems. Over the past few years, EPB completed a survey on atmosphere, water, ecology, noise, light pollution, and waste problems. This survey analyzed public, government, and experts opinions to set up the following ten-year environmental protection plan (EPB 2012a, EPB 2012b, EPB 2012c), which focuses on reducing energy consumption and pollution, and improving the living environment to create a "low carbon" and green community for living and recreation. This survey served as my first guideline and induced me to understand more about citizens' ideas and opinions on the environment. In order to understand how residents' opinions may help on the environment, I decided to choose one aspect of the environment - urban forestry - to study deeply about residents' perception and suggestions for urban forests in Macao.

My project focuses on the understanding of residents' perception of urban greening in Macao. I will determine how Macao residents of different genders and educational levels residing in different parts of the city perceive current green space. Residents can provide detailed information about their needs and any potential problems with current greening methods encountered during their daily experiences. By cooperating with local communities and integrating their ideas in city planning, the government will be able to provide a greener environment for its citizens. My findings will suggest methods for improving greening practices in existing areas, and planning and designs strategies for new areas to satisfy residents' needs and wants.

METHODS

Site description

Macao lies in a subtropical zone with a short winter and long summer. Typically, Macao experiences northerly wind, cold and dry weather with low rainfall in winter, and hot and humid summers with heavy rainfall. Typhoons impact Macao in the summer (from May to October), and most often in July and August (Government Information Bureau 2011).

The urban environment in Macao, especially in the Macao peninsula, consists of narrow alleys and densely spaced buildings, and contains several historically valuable buildings. In the old city core of the west and central parts of Macao peninsula, the buildings, both residential and commercial, are generally from five to ten stories tall. When the city was initially built, the streets were narrow and contained few cars. At that time, the Portuguese government did not have a city plan for Macao because the Portuguese were using Macao as a place for trading and accessing China. This led to a chaotic and unorganized infrastructure with many residential buildings next to commercial buildings or even casinos. Urban planning is complicated because most of Macao's World Heritage sites are inside or near residential areas. Macao government should consider these constraints when choosing plant species and sites, operation and maintenance costs, and other factors related to the built environment. For example, the tree species for streets should be able to resist the wind in typhoons, or supported by wood frames so

that the trees would not fall. The government cannot plant large trees in the compact part of the old city core since there is not enough space for citizens to walk and the trees to grow.

The Instituto para os Assuntos Civicos e Municipais (IACM, institution for civic and municipal issues) divided the current urban green spaces in Macao into four categories: (1) green space for leisure and recreation, (2) green space for traffic infrastructure, (3) green space for wildlife habitat, and (4) nurseries to provide plants for urban greening (EPB 2010). Additionally, IACM counted vertical greening, such as rooftop gardens and vines on fences, as a new type of greening method (EPB 2010). In the Macao peninsula, two primary urban forestry programs currently exist. The first program aims to improve the old developed areas (areas that have been developed over fifty years ago) through vertical greening, trees, and small parks to create a "green network". Vertical greening includes rooftop gardens, fences with vines, and flower pots hanging on streetlamps. The second program consists of planning future developments with more high quality green space that addresses residents' needs and wants. In Taipa Island, Coloane Island, and Cotai, the current planning of urban greening focuses on incorporating green space and maintaining the large ecological green spaces for birds and other animals' habitats.

Survey Distribution

To obtain information about current urban forestry practices and residents' perceptions of urban forestry in Macao, I distributed surveys to city residents using both probability and non-probability sampling methods in December 2012 and January 2013. I went to several regions of Macao to survey residents - three sites in the older developed parts of Macao peninsula, and one site in newly developed parts of Macao peninsula. I printed 350 surveys and asked people in streets and public areas, including Macau SAR Identification Department and Macao Central Library. I used probability sampling by asking one of every three people I passed in streets and public areas. I used the snowball sampling method (non-probability sampling) by giving out surveys to my friends and asking them to give copies of surveys to their families and friends, so that more people would have an opportunity to respond. A copy of the entire survey can be found in the Appendix. Appendix A is the Chinese version, and Appendix B is the English version.

Survey Content

To understand the current perception, problems and possible solutions of urban forestry in Macao, the first section (Section I) of my survey consisted of three parts. Part one included questions about residents' current satisfaction and general perception of urban forestry in Macao. I used categorical questions (with respondents choosing all suitable answers) to determine opinions about the importance of environmental improvements, and preferences for placement of vegetation within existing open spaces. For example, I asked "Which of the following environmental improvement(s) do you think is/are important? (Please check all that apply.)" and I gave five options from which survey participants could choose: 1) improve air quality, 2) more open green space, 3) create attractive streetscapes, 4) reduce runoff and flooding, and 5) create more bird habitats. In addition to categorical questions, I used Likert scale questions (1-5 points, for which 1 point is mostly disagree and 5 points is mostly agree) to find out residents' satisfaction with current urban green space. For example, the survey asked residents to compare the current urban forestry practices to past practices.

To gather citizen input related to preferences for individual tree species and streetscape styles, Section I part two included categorical questions (wit respondents choosing all suitable answers) about preferences of streetscapes and tree shapes in parks and streets. I prepared pictures of different streetscapes, greening methods, and tree shapes by sketching various shapes of trees, plants and streetscapes. I placed these pictures in the survey to show survey participants the different options available. These images allowed survey participants to understand types of greening methods and tree shapes available in Macao, and state their preferences. For example, I asked "If planting trees in parks and recreational areas, which tree shape(s) do you like? (Please check all that apply.)" and I provided a series of tree shapes with boxes below each tree shape for survey participants to check their favorites.

To understand problems with current greening methods, and potential suggestions for urban forestry in Macao, Section I part three included categorical questions about problems and potential solutions or improvements of Macao urban forestry practices. The first question asked whether participants like certain greening methods (e.g., trees, shrubs, vertical greening, hanging flower pots, and flower pots on ground). These questions required yes or no responses for each option; and if they answered "no" for one or more greening methods, then they were required to

answer an additional two questions. The additional two questions asked about problems with their disliked greening method(s) and potential solution(s) for the problems. I also included an open-ended question about which improvements the survey participants would prefer.

To obtain information for comparison between my study groups, Section II included questions about personal, demographic, and behavioral information. I asked about gender, age groups, neighborhood of residence, type of residence, and current behaviors. These questions served as my study groups and I compared the differences among and between the groups.

Data Analysis

For each part of my survey, I obtained general summaries of data and determined the differences between my study groups (e.g., gender, age, educational levels, and current place of residence). I used mostly descriptive statistics to analyze my data (Table 1). For all categorical questions, I counted the numbers of surveys for each option, and determined the most preferred selection for that question. I then plotted the data into tables or bar graphs to reveal the difference between the groups.

Table 1. Summaries of data analysis.

Data	Data analysis method	Findings
Section I part 1	Descriptive statistics and ANOVA	Preferences for environmental improvements and plantation sites; satisfaction with current green spaces
Section I part 2	Descriptive statistics	Preferences for vegetation types
Section I part 3	Descriptive statistics	Problems with current greening methods; potential solution or suggestions

To compare the different perceptions among my study groups, I inputted my data into a Microsoft Excel spreadsheet and compared the data. I used descriptive statistics and graphics to show the differences in preferences between study groups with variations in the following characteristics: age, gender, education level, time spent outdoors, and residence location. For comparison between study groups, I first separated the raw data into several sets, in which one set contained all answers for one particular variable. For instance, I separated my data into two sets: one set only contained male respondents, while the other only contained female respondents.

Then I did the same counting for these two sets separately, and compared the counts to determine if there was difference between groups.

I used summaries of all the above analysis and the open-ended questions to explain the current main problems and the most suitable solutions or improvements to the urban forestry in Macao. This strategy enabled me to present a list of preferred, non-preferred, and disliked options, as well as make suggestions for future planning or organization of urban green space for Macao. Additionally, I used the data comparisons between different living areas to make specific suggestions for urban green space planning for different areas in Macao.

RESULTS

Demographics

I received 218 filled questionnaires out of the 350 I sent out, with 33 done in public places by random sampling and the rest done by snowball sampling. Within all surveys, only 7 (3.2%) respondents were non-residents (Table 2). 107 (50.7%) of resident survey participants were female, and 104 (49.3%) were male. Most of the resident respondents (58.3%) were between the ages of 18 and 45, while 20.9% were between ages of 46-64, and the remaining were younger than 18 (18.5%), and older than 64 (2.4%). 91.9% of resident survey participants had at least high school education. 44.5% of resident survey participants lived in the central area of Macao peninsula. As the non-resident respondents were only a very small group in the data set and my research focus was about residents' perception, I decided to disregard those 7 surveys. The analysis presented here included only resident respondents (from herein "respondents" or survey participants").

Table 2. Demographic summaries.

Demographic variables	Number of survey respondents (percentage)	Number of survey respondents who are Macao residents (percentage)
Local		
Residents	211 (96.8)	211 (100)
Non-residents	7 (3.2)	/
Gender		
Male	108 (49.5)	104 (49.3)
Female	110 (50.5)	107 (50.7)
Age Group		
0-17	39 (17.9)	39 (18.5)
18-45	129 (59.2)	123 (58.3)
46-64	45 (20.6)	44 (20.9)
65+	5 (2.3)	5 (2.4)
Highest Educational Level		
Primary school graduate or lower	17 (7.8)	17 (8.1)
High school graduate	123 (56.4)	121 (57.3)
Bachelor's degree	60 (27.5)	56 (26.5)
Master's degree or higher	18 (8.3)	17 (8.1)
Living Area		
Macao Peninsula		
Northeast area	43 (19.7)	42 (19.9)
Northwest area	29 (13.3)	28 (13.3)
Central area	94 (43.1)	94 (44.5)
West area	8 (3.7)	8 (3.8)
Southeast area	7 (3.2)	6 (2.8)
South area	9 (4.1)	8 (3.8)
Taipa Island	26 (11.9)	25 (11.8)
Coloane Island	0 (0.0)	0 (0.0)
Time Spent Outdoors (per week)		
0-5 hours	69 (31.7)	65 (30.8)
5-10 hours	75 (34.4)	74 (35.1)
10-20 hours	48 (22.0)	48 (22.7)
20+ hours	26 (11.9)	24 (11.4)
Time Spent in Parks (per week)		
0-5 hours	172 (78.9)	166 (78.7)
5-10 hours	36 (16.5)	35 (16.6)
10-20 hours	7 (3.2)	7 (3.3)
20+ hours	3 (1.4)	3 (1.4)

Satisfaction with current greening practices

I found my respondents had similar levels of satisfactions with respect to current urban greening in Macao. The average score for satisfaction with current green spaces was 2.72, and the respondents were also slightly dissatisfied with the current greening methods, with an average score of 2.76 (Fig. 2). They thought the overall urban greening and the environment has been improved (average score of 3.24 and 3.12, respectively). They preferred staying outdoor environment for a shorter time period (average score of 2.70). There were no significant difference between my study groups (P-value>0.05).

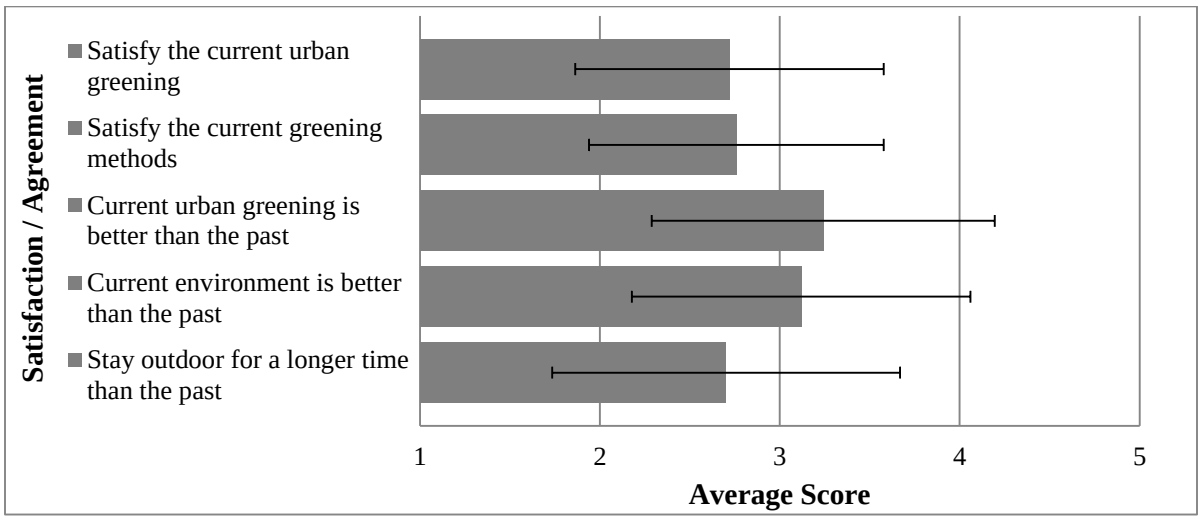

Fig. 2. Summary of satisfaction with current greening practices. Average score: 1 = strongly dissatisfy/disagree, 2 = dissatisfy/disagree, 3 = neutral, 4 = satisfy/agree, 5 = strongly satisfy/agree.

General summaries of perceptions

My survey showed that the majority of residents of Macao were interested in increasing Macao's urban green spaces (99.1%). Most of the survey participants (89.1%) chose improving air quality as the environmental improvement that concerned them the most, while few of them (21.8%) concerned about runoff and flooding (Table 3).

Table 3. Summary of environmental improvements. Participants checked all that apply.

Environmental improvements	Number of residents (percentage)
Improve air quality	89.1
More open green space	68.7
Create attractive streetscapes	32.7
Create more bird habitats	29.9
Reduce runoff and flooding	21.8

I found that 99.1% of respondents hoped to see more trees and plants in Macao's landscape. They chose "streets" as the most preferred location to see more vegetation, while "parks and gardens" was their second most preferred option (Fig. 3). The most preferred streetscape was planting trees on both sides of streets, with 53.1% respondents, while the following favorite streetscapes were having recreational areas in between the roads and planting trees in the traffic medians, with 41.7% and 41.2% respondents selected respectively. 70.8% of survey participants thought their neighborhoods needed more greening. Residents living in West, Southwest, Northwest, and Northeast areas of Macao peninsula especially felt their neighborhoods lacked green space, with 100%, 100%, 89.3%, and 71.4% respondents respectively.

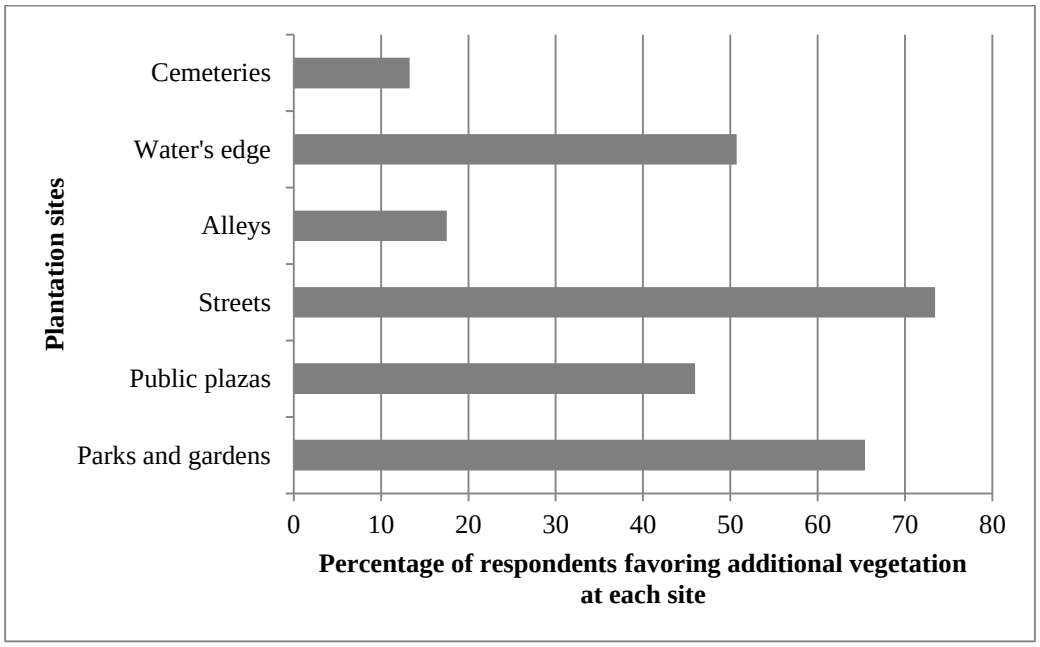

Fig. 3. Locations residents would most prefer to see more vegetation. Participants checked all that apply.

In the open-ended question, many people asked for more trees, improvements to the green spaces, and some specific opinions to the city planning. They generally asked for more plantations, especially trees, to improve air quality. They also suggested to plant local species instead of foreign species. They hoped the rural land would be kept for parks and recreational areas instead of turning them into casinos. Some of them wanted to plant trees on both sides of streets and more vegetation densely-populated areas, but others thought the trees on street sides would block the drivers' sight and small areas of vegetation in the compact areas could not help greening the city. Some of them suggested that the government invite professionals and experts to discuss the greening and trees in Macao. Another suggestion would be to encourage and teach individuals, schools, and building owners to use vertical greening and plant more vegetation on the terraces, podiums, and rooftops.

Preference for vegetation types

The responses to the questions about tree and plant preferences varied according to proposed planting sites. Evergreen trees and flowering plants were the most preferred vegetation for both parks and streets (Table 4).

Table 4. Summary of preferred vegetation in parks and streets. Number of participants shown. Participants checked all that apply.

	Deciduous trees	Evergreen trees	Shrubs	Flowering plants	Non-flowering plants
Parks	86	149	81	149	25
Streets	43	122	66	103	37

Elder people tended to less prefer shrubs, flowering plants and non-flowering plants in parks. Respondents who spent more time outdoors preferred planting deciduous trees and shrubs in parks, while respondents who spent more time in parks preferred to plant less deciduous trees in parks. For streets plantation, elder people tended to less prefer all types of vegetation. Survey participants with higher educational level tended to prefer planting evergreen trees in streets. People spending more time outdoors tended to prefer more deciduous trees in streets, while people spending more time in parks tended to prefer evergreen trees, shrubs, and flowering plants in streets. Round-headed trees were the most preferred tree shape for both park and streets. Palm-shaped trees were the most disliked tree shape for both sites (Table 5, Fig. 4, Fig. 5).

Table 5. Summary of tree shapes preferences and dislikes. Number of participants shown. Participants checked all that apply.

	Tree shapes							
	Round-headed	**Oval**	**Vase-shaped**	**Columnar**	**Conical**	**Pendulous**	**Multi-stemmed**	**Palm-shaped**
Preference								
Park	159	57	71	50	108	34	50	64
Street	96	77	44	62	50	20	17	60
Dislike								
Park	6	15	52	32	22	61	46	84
Street	18	10	70	13	40	63	68	75

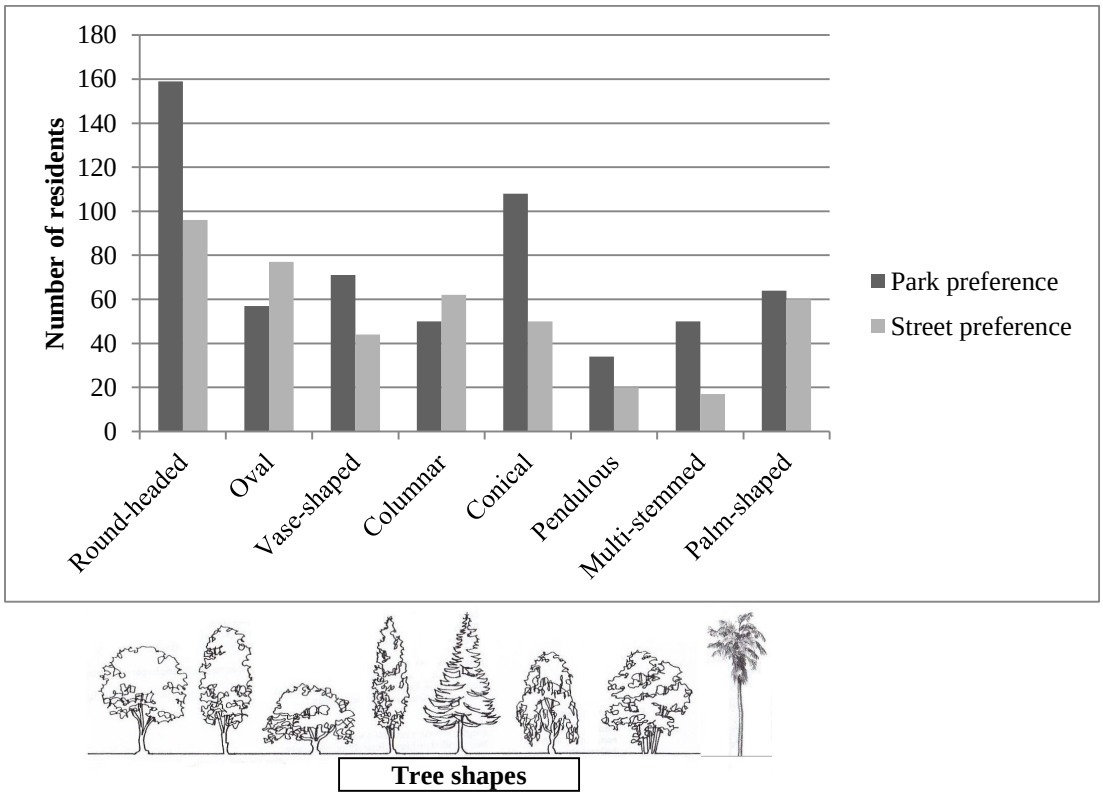

Fig. 4. Tree shape preferences.

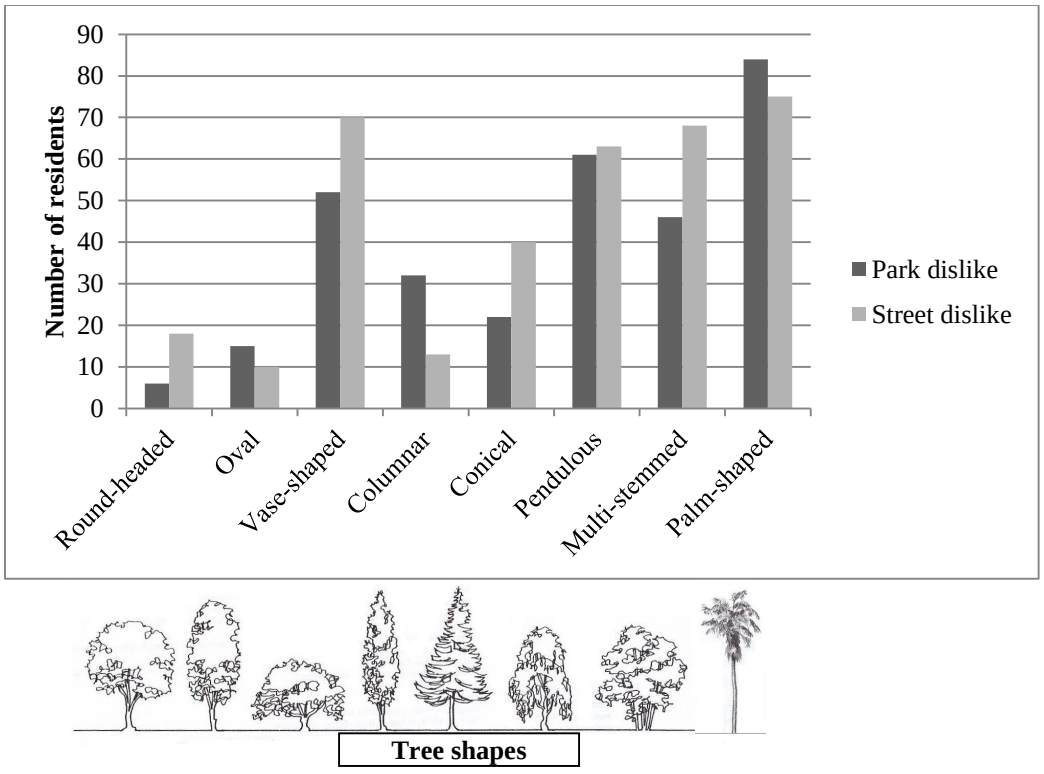

Fig. 5. Disliked tree shape.

Perceptions of current greening methods

Perceptions of current green methods in Macao varied little according to my study groups. Teenagers and elder people tended to identify more problems of current greening methods than the people in the age group of 18 to 45. Overall, most respondents (90.0%) preferred trees, while many respondents (63.5%) disliked flower pots on ground because of blocking the pathways and piling up rubbish (Table 6, Fig. 6). My survey identified that respondents were most concerned about the flowerpots on ground, and they preferred not to use this greening method and switched to other greening methods (Fig. 6, Fig. 7).

Table 6. Summary of preference of greening methods. Number of participants shown. Participants checked all that apply.

	Greening methods				
	Trees	Shrubs	Vertical greening	Hanging flower pots	Flower pots on ground
Like	190	161	163	151	77
Dislike	21	50	48	60	134

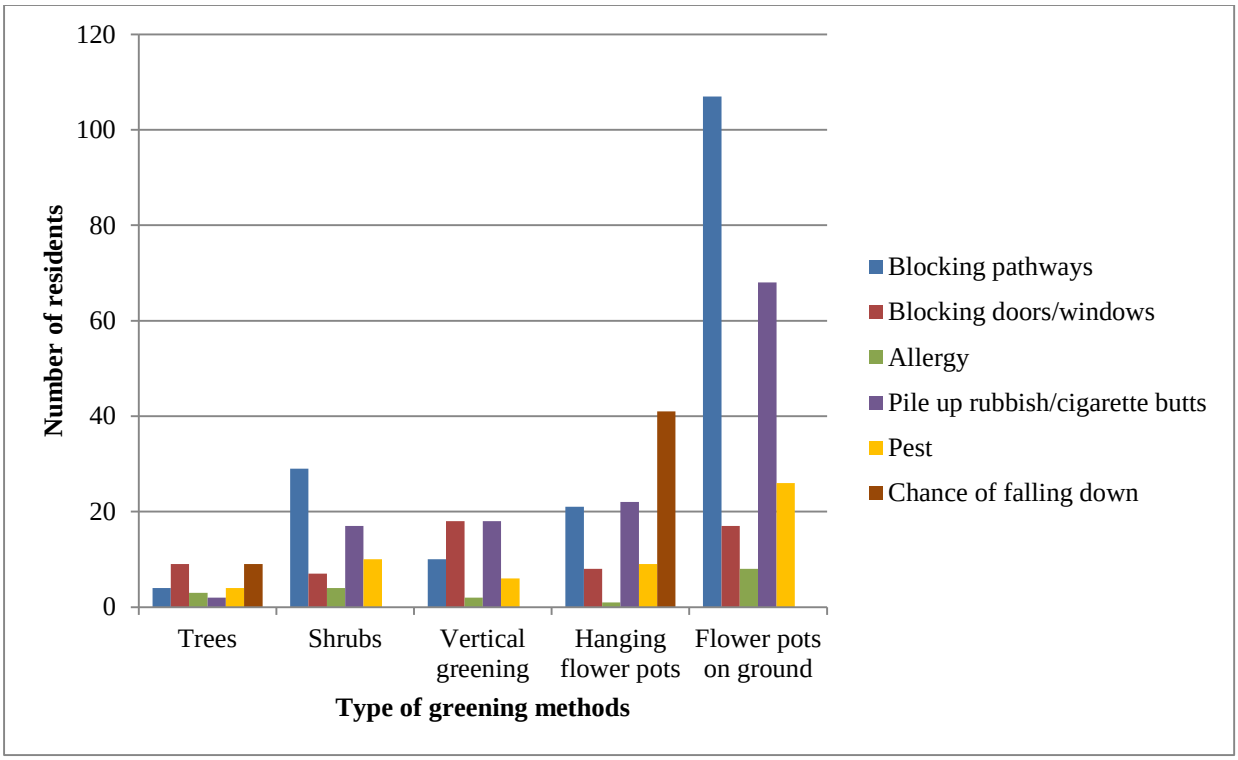

Fig. 6. Problems with different greening methods. Participants checked all that apply.

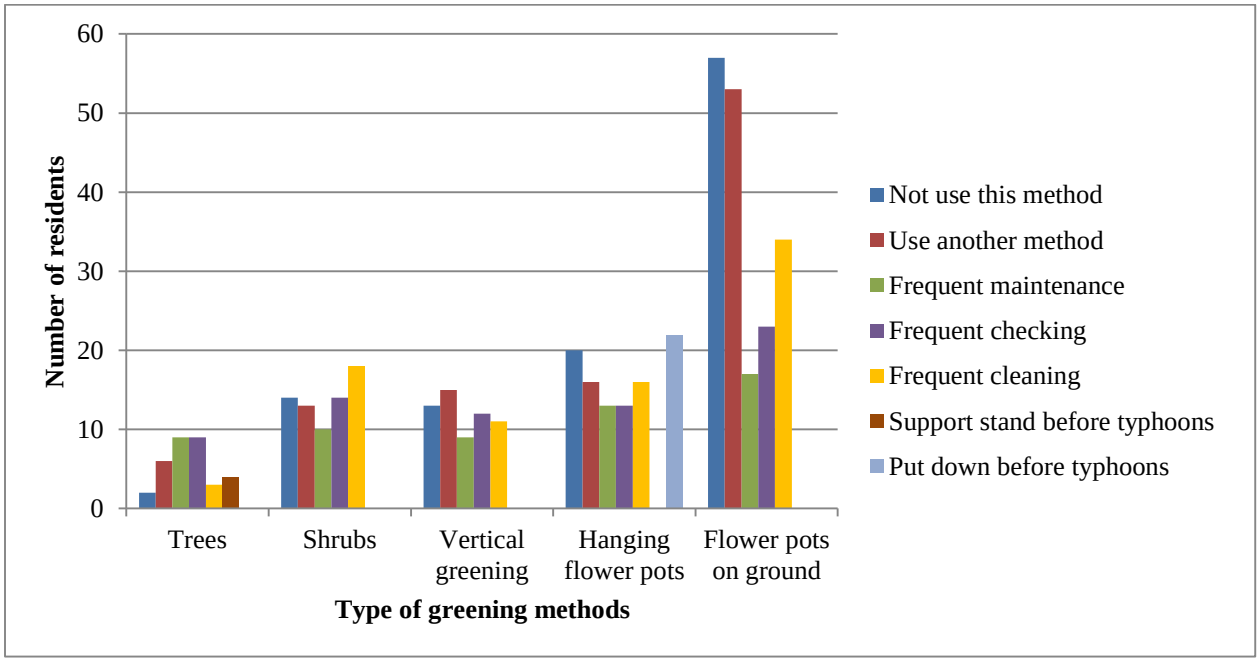

Fig. 7. Preferred improvements to solve the problems of current greening methods. Participants checked all that apply.

DISCUSSION

My research showed that most respondents were slightly dissatisfied with current urban forestry practices because of lack of green space in Macao. Although many had noticed the recent improvements, survey respondents wanted more vegetation in Macao. Most respondents preferred trees, such as evergreen trees and round-headed trees, planting in streets and parks. My research also showed little difference in residents' perceptions of urban forestry, plant choices, identification of problems and solutions to current greening methods between my study groups except for age. Government needs to carefully consider the situations in each area of Macao in order to construct new green spaces or reconstruct the old green spaces in Macao.

Perception of current greening practices

Residents' perception of urban greening in my research was similar to the survey done by the Macao Environmental Protection Bureau and another similar survey done in Hong Kong. Participants in all three surveys mentioned the air quality problem and expectation of more vegetation to improve air quality (EPB 2012b, Lo and Jim 2012). The air quality problem has existed for years but residents did not notice the improvements because similar poor air quality of nearby cities and increase of vehicle amount balanced the improvements in reducing pollutants and greenhouse gas emission. In addition, both my survey respondents and the EPB survey indicated that government should increase efforts to improve and promote ecological functions of urban green space (EPB 2012a). The green patches in the Macao peninsula did not function as well as the ecological zone in the Cotai reclamation area and the large forest in Coloane Island because of small sizes and disconnectedness. The green spaces would work more efficiently if the government constructs green corridors to connect the patches. Furthermore, the participants in the EPB survey mentioned the current environment was uncomfortable and discouraged citizens from walking in the streets because of lack of green space (EPB 2012a). This supported my finding regarding time residents spent outdoors (i.e., they were willing to stay outdoors for less time in recent years compared to prior years).

Residents provided varying responses and listed a variety of suggestions for urban greening in different regions of Macao, and the EPB survey suggested similar ideas. In the EPB

survey (EPB 2012a), most respondents mentioned the lack of green spaces in Macao peninsula, and my survey respondents agreed. For Taipa Island, some respondents said the green space was decreasing, while half of my survey respondents had similar perception, and the other disagreed. However, the Report on the State of the Environment of Macao 2010 reported increasing green space for all parts of Macao for the past few years. Some developing areas have been reducing green space, while the government was planting in the other parts of Taipa Island; thus the survey participants had conflicts in answering this question. As for suggestions, both survey respondents recommended creating small green belts or corridors to connect the green spaces in the compact areas of Macao peninsula (Jim 2004), which was similar to the Beijing case of Xu et al 2011. A small group of my respondents suggested rooftop gardens for Macao peninsula, which was also supported in the EPB survey (EPB 2012a). Vertical greening, including rooftop gardens, may work efficiently to connect the green patches in Macao peninsula. However, many buildings in Macao may not be suitable for green roof construction because the roofs lack various factors, such as bearing strength and ability to prevent root penetration, for vegetation to grow on the roofs. Macao EPB has constructed green roofs on the rubbish collecting houses in recent years to test feasibility of promoting green roofs on newly constructed buildings.

Reconciliation of ideas and opinions

My survey results indicated the need to reconcile perceived advantages and disadvantages of increasing urban tree cover. Most respondents wanted more vegetation and trees in Macao, but they had very different opinions about the plantation sites and plant choices. Many people preferred to have more trees in streets but were afraid that the trees would take a lot of space and narrow streets. The drivers thought the trees in the traffic medians and near street intersections would block their sight of other vehicles. They suggested reducing the trees near streets; on the other hand, my results showed that planting trees in traffic medians and on street sides were the most preferred streetscapes. Many respondents had mixed opinions in the shapes of trees. Some of them preferred palm-shaped trees because they are tall and straight, while others thought of the pest problem and disliked leafless trees. These differing opinions suggested that some residents would be dissatisfied with the plans even though the plans have tried to incorporate all residents' opinions. The government should do follow-up surveys to understand

residents' satisfaction with the new plans and decide whether these plans fulfill residents' wants and whether the plans require any changes.

Limitations

My research survey was limited in scale, sampling method, and representation. Compared to the large population in Macao, my survey only covered a very small amount of residents. Although I used both random sampling and snow-ball sampling, most of my questionnaires are done by snow-ball method, which resulted in some bias due to the high representation of my social network in the survey sample. In addition, I rarely reached the group of elder people (i.e., over the age of 65) because they often stayed in their home and they might not be able to read. During my survey, I also found that many people were unwilling to take the survey because they thought it was time-consuming and unlikely to mitigate their perceived problems.

Suggestions for future environmental management and planning

My survey respondents generally requested for more vegetation, especially trees, and the mains issues are how and where to plant them. I suggest planting tall trees with small tree canopies in traffic medians and no trees at the intersections. If the sidewalks are wide enough, planting trees on one or both sides of the streets is also recommended. I recommend not using hanging flower pots and flower pots on the ground in the narrow streets of old developed areas in Macao peninsula, because many respondents complained about the blocking problems of the flower pots. As most people who were complaining about their neighborhood not having enough green space were living in the old developed areas with densely spaced five-story apartments, it would be very difficult to put in a large scale of green space in these areas. I suggest turning some alleys into walking zone with shrubs and vertical greening, such as vines on fences or walls. I would suggest planning a small park for nearby residents to use in each compact area.

My survey respondents provided many useful suggestions for improving urban green spaces in Macao. Introducing vertical greening and rooftop gardens, building green belts and corridors to link green patches in Macao peninsula, planting tree species that can absorb air pollutants, and improving hanging flower pots on street fences are some general suggestions in

the open-ended question of my survey. More specific recommendations included planting wind-resistant trees in case of blown down by typhoons, hiring professionals of trees and plants to choose plant species for green spaces in Macao, and encouraging the owners of buildings to use podium greening for beauty and better air quality. A few respondents preferred using fewer flowers in streets because flowers require frequent maintenance. One survey participant suggested developing seashore as a planted trail for recreation and exercise.

Many survey respondents cared about the plant species used for green spaces in Macao, and the Department of Gardens and Green Areas (G. Pang, personal communication) considered plant choice as a tough question in the planning process. The widely varying and sometimes contradictory responses made the plant choice question even tougher. I suggest planting flowering plants and round-headed trees in the parks, and oval and columnar evergreen trees in the streets. Although round-headed trees were the most preferred tree shape for streets, I would suggest not planting them in the traffic medians because some drivers complained the trees blocked their sights.

Frequent maintenance and cleaning are very important to maintain a clean city for citizens and tourists. Many respondents chose frequent maintenance, checking, and cleaning for solutions and improvements for the problems of current greening methods. Rubbish piles were one of the main problems noticed by my respondents. Frequent cleaning could relieve this situation temporarily, while educating residents to help keeping Macao as a green city and strictly enforcing the Public Place Regulation policy to prevent people from throwing rubbish in streets would solve this problem from its root. Frequent maintenance and checking would allow governmental departments to nurse trees and plants, set up wood frames to prevent small and old trees being blown down by typhoons, and notice problems, such as pests and plant diseases, to solve the problems before they become worse.

Future Directions

Ideas for future research include surveys on smaller areas, specific greening methods, and cooperation with nearby cities. Research on smaller areas can provide more detailed information about problems within each living area in order to offer specific plans for each area. Specific greening methods surveys, such as vertical greening (a method with which many citizens are

unfamiliar), can allow residents to learn more about greening methods provided by the government. In addition, cooperating with nearby cities, with which the Macao government has been working, such as Hong Kong and Zhuhai, allows a total improvement of larger zones instead of small-scale improvements.

Conclusions

My research provided evidence of residents' dissatisfaction about current greening practices and residents' proposed suggestions to solve the problems and improve Macao's green spaces. Their opinions could be integrated to improve current greening methods and future green space planning. Reducing tree plantation in traffic medians, introducing rooftop gardens and green corridors, and planting round-headed trees in parks and streets are some of my respondents' suggestions. It is important to understand that we cannot satisfy all residents' wants because some of their opinions may conflict with each other. Future research of smaller living areas and specific greening methods are recommended to understand the wants and needs of different citizens residing in different living areas thoroughly. My research understood citizens' basic perceptions of urban forestry in Macao and provided feasible suggestions to improve Macao's green spaces, which can serve as a progress to improve the whole environment in Macao.

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APPENDIX A: Chinese Version of Questionnaire

澳門市區綠化問卷調查

本人是一名在讀的大學生，為了了解澳門市民對市區的環境綠化的滿意程度及意見，而作此問卷調查。

第一部分

1. 你認為以下哪種改善環境的需求比較重要：**(可多選)**
- ☐ a. 改善空氣質素
- ☐ b. 更多綠化空間
- ☐ c. 改善街道景觀
- ☐ d. 減少水土流失
- ☐ e. 為鳥類提供棲息地

2. 你希望在澳門戶外見到更多樹木及植物嗎? (若否, 請跳至第 3 題)
- ☐ 是
- ☐ 否

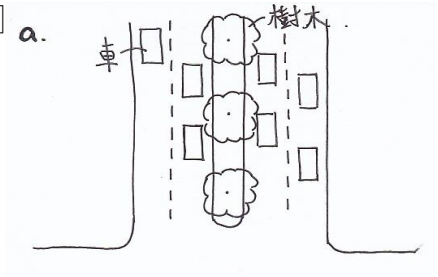
2A. 你希望在哪些地方見到更多樹木及植物? **(可多選)**
- ☐ a. 公園及花園
- ☐ b. 廣場
- ☐ c. 街道
- ☐ d. 小巷
- ☐ e. 水塘及海邊
- ☐ f. 墳場

以下第 3 至 7 題為評分題。(評分：1-5 分，1 分為非常不滿意/不同意，5 分為非常滿意/同意)

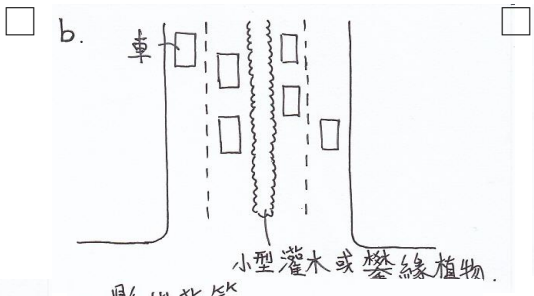
3. 對於本澳的市區綠化大體上滿意嗎？	1	2	3	4	5
4. 對於本澳的市區綠化方式滿意嗎？	1	2	3	4	5
5. 和過去相比, 更滿意現在的綠化。	1	2	3	4	5
6. 和過去相比, 認為現在的環境有改善。	1	2	3	4	5
7. 和過去相比, 會在室外逗留較長時間。	1	2	3	4	5

8. 你喜歡哪種街道設計/景觀? **(可多選)**

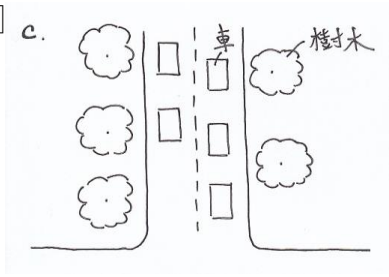
☐ a.



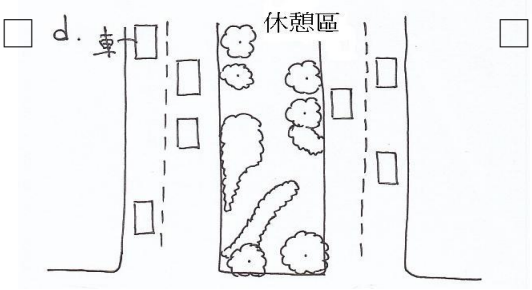
☐ b.



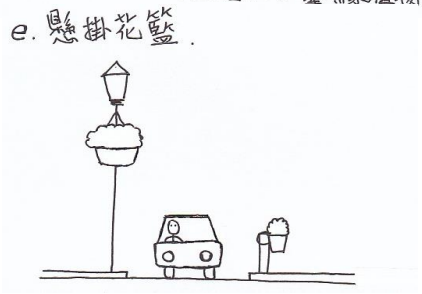
☐ c.



☐ d.

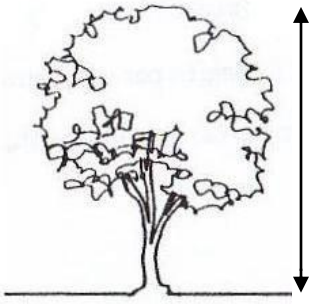


☐ e.

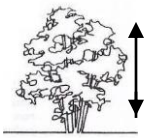


9. 如果政府提供以下各種植物由你選擇, 你會選擇哪種種植在 公園或其他休憩場所? **(可多選)**

- ☐ a. 落葉喬木
- ☐ b. 常綠喬木
- ☐ c. 灌木
- ☐ d. 開花植物
- ☐ e. 不開花植物

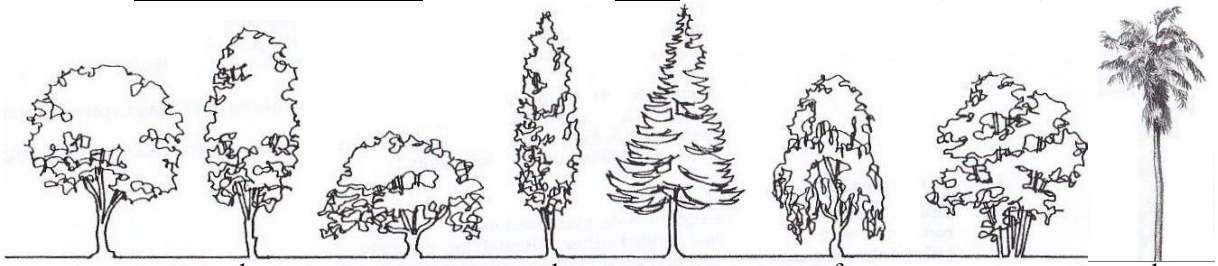


喬木: 常見的大樹, 一般主樹幹明顯, 高度 5 米或以上



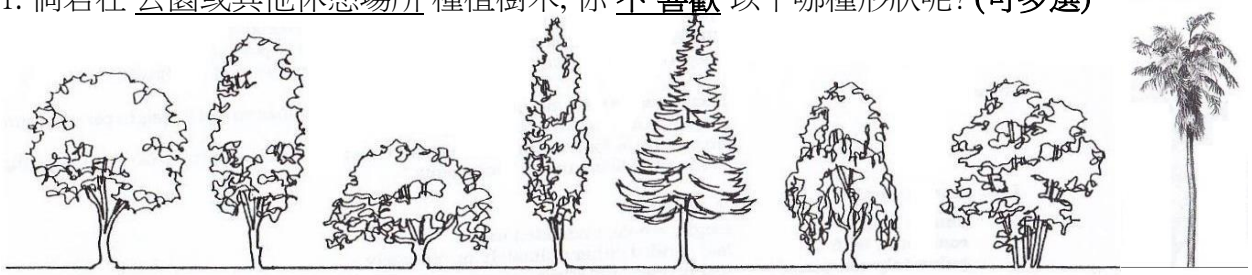
灌木: 一般主樹幹不明顯, 在基部發出多個枝幹, 高度 5 米以下

10. 倘若在 公園或其他休憩場所 種植樹木, 你 **喜歡** 以下哪種形狀呢? **(可多選)**



a. ☐ b. ☐ c. ☐ d. ☐ e. ☐ f. ☐ g. ☐ h. ☐

11. 倘若在 公園或其他休憩場所 種植樹木, 你 **不 喜歡** 以下哪種形狀呢? **(可多選)**

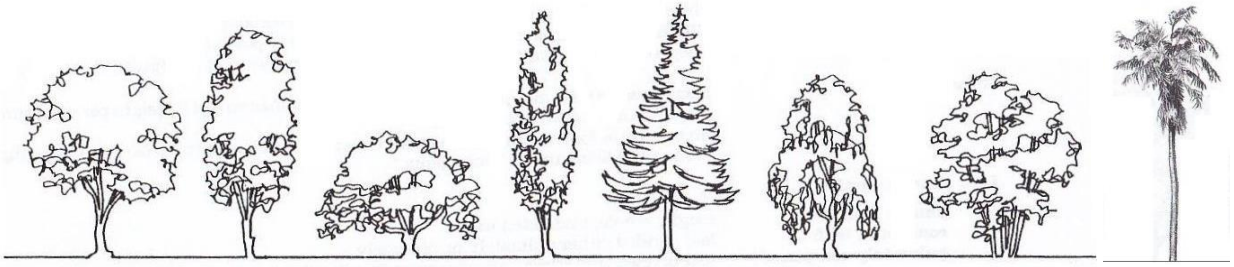


a. ☐ b. ☐ c. ☐ d. ☐ e. ☐ f. ☐ g. ☐ h. ☐

12. 如果政府提供以下各種植物由你選擇, 你會選擇哪種種植在 街道或行人道? **(可多選)**

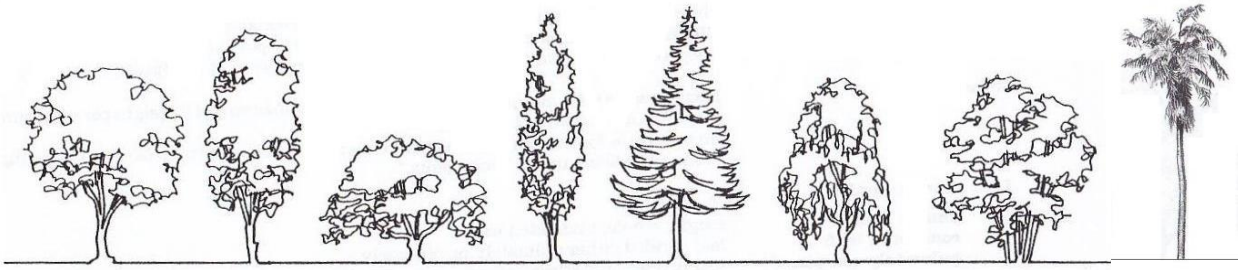
☐ a. 落葉喬木 (喬木: 常見的大樹, 一般主樹幹明顯, 高度 5 米或以上)
☐ b. 常綠喬木
☐ c. 灌木 (一般主樹幹不明顯, 在基部發出多個枝幹, 高度 5 米以下)
☐ d. 開花植物
☐ e. 不開花植物

13. 倘若在 街道或行人道 種植樹木, 你 **喜歡** 以下哪種形狀呢? **(可多選)**



a. ☐ b. ☐ c. ☐ d. ☐ e. ☐ f. ☐ g. ☐ h. ☐

14. 倘若在 街道或行人道 種植樹木, 你 **不 喜歡** 以下哪種形狀呢? **(可多選)**



a. ☐ b. ☐ c. ☐ d. ☐ e. ☐ f. ☐ g. ☐ h. ☐

15. 你認為在你居住的街道及鄰近街道中有足夠綠化空間嗎?

☐ 是 ☐ 否

16.	是否喜歡下列的綠化方式？ (請回答每一個小問。若有任何一題答否, 請回答第 17 和 18 題的相應部分)	是	否
	16a. 喬木 (常見的大樹, 一般主樹幹明顯, 高度 5 米或以上)		
	16b. 灌木 (一般主樹幹不明顯, 在基部發出多個枝幹, 高度 5 米以下)		
	16c. 立體綠化 (如垃圾房上的蔓藤)		
	16d. 懸掛花盆/花籃		
	16e. 地上擺放花盆		

17.	不喜歡上一題(第 16 題)的綠化方式的原因：**(可多選)**	
	17a. 喬木	☐ i. 妨礙行人 ☐ ii. 遮擋門口或窗戶 ☐ iii. 花粉敏感 ☐ iv. 堆積垃圾或煙頭 ☐ v. 蟲害 ☐ vi. 倒塌的危機
	17b. 灌木	☐ i. 妨礙行人 ☐ ii. 遮擋門口或窗戶 ☐ iii. 花粉敏感 ☐ iv. 堆積垃圾或煙頭 ☐ v. 蟲害
	17c. 立體綠化	☐ i. 妨礙行人 ☐ ii. 遮擋門口或窗戶 ☐ iii. 花粉敏感 ☐ iv. 堆積垃圾或煙頭 ☐ v. 蟲害
	17d. 懸掛花盆/花籃	☐ i. 妨礙行人 ☐ ii. 遮擋門口或窗戶 ☐ iii. 花粉敏感 ☐ iv. 堆積垃圾或煙頭 ☐ v. 蟲害 ☐ vi. 掉下的危機
	17e. 地上擺放花盆	☐ i. 妨礙行人 ☐ ii. 遮擋門口或窗戶 ☐ iii. 花粉敏感 ☐ iv. 堆積垃圾或煙頭 ☐ v. 蟲害

18.	你認為應如何改善上一題(第 17 題)所述的問題：**(可多選)**	
	18a. 喬木	☐ i. 不使用這種綠化方式 ☐ ii. 改用另一種綠化方式 ☐ iii. 經常養護 ☐ iv. 經常檢查 ☐ v. 經常清理 ☐ vi. 於颱風前進行加固
	18b. 灌木	☐ i. 不使用這種綠化方式 ☐ ii. 改用另一種綠化方式 ☐ iii. 經常養護 ☐ iv. 經常檢查 ☐ v. 經常清理
	18c. 立體綠化	☐ i. 不使用這種綠化方式 ☐ ii. 改用另一種綠化方式 ☐ iii. 經常養護 ☐ iv. 經常檢查 ☐ v. 經常清理
	18d. 懸掛花盆/花籃	☐ i. 不使用這種綠化方式 ☐ ii. 改用另一種綠化方式 ☐ iii. 經常養護 ☐ iv. 經常檢查 ☐ v. 經常清理 ☐ vi. 於颱風前拿下放在地上
	18e. 地上擺放花盆	☐ i. 不使用這種綠化方式 ☐ ii. 改用另一種綠化方式 ☐ iii. 經常養護 ☐ iv. 經常檢查 ☐ v. 經常清理

19. 其他改善澳門市區綠化的意見:

_____

_____

_____

_____

_____

第二部分

1.	請問你是：			
	☐ a. 本地居民	☐ b. 非本地居民		
2.	性別：			
	☐ a. 男	☐ b. 女		
3.	年齡：			
	☐ a. 0-17	☐ b. 18-45	☐ c. 46-64	☐ d. 65 或以上
4.	最高學歷：			
	☐ a. 小學畢業	☐ b. 中學畢業	☐ c. 學士學位	☐ d. 碩士學位或以上
5.	請問你所居住的地區是：(請看下面的地圖)			
	☐ a. 澳門東北區 ☐ e. 新口岸填海區 ☐ i. 不知道，街名: _____	☐ b. 澳門西北區 ☐ f. 南灣及媽閣區	☐ c. 澳門市中心區 ☐ g. 氹仔區	☐ d. 澳門新馬路區 ☐ h. 路環區
6.	請問你每週會在室外逗留多長時間?			
	☐ a. 0-5 小時	☐ b. 5-10 小時	☐ c. 10-20 小時	☐ d. 20 小時以上
7.	請問你每週會在 公園或其他休憩場所 逗留多長時間?			
	☐ a. 0-5 小時	☐ b. 5-10 小時	☐ c. 10-20 小時	☐ d. 20 小時以上

以上的資料僅供這次調查使用，任何個人資料絕對保密，不會對外公開。

APPENDIX B: English Version of Questionnaire

Macao Urban Greening Survey

My name is Hoi Kuan Fong. I am a senior student major Environmental Sciences in University of California, Berkeley. This survey is intended to understand Macao residents' perception on urban forest in Macao.

Section I

1. Which of the following environmental improvement(s) do you think is/are important? (Please check all that apply.)
   - □ a. Improve air quality
   - □ b. More open green space
   - □ c. Create attractive streetscapes
   - □ d. Reduce runoff and flooding
   - □ e. Create more bird habitats

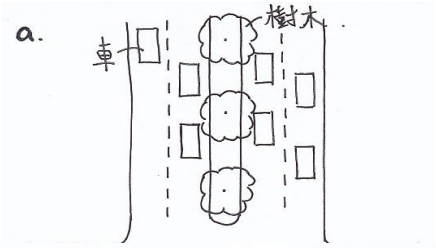
2. Would you like to see more trees and plants on Macao streets? (If no, please jump to question 3.)
   - □ Yes
   - □ No

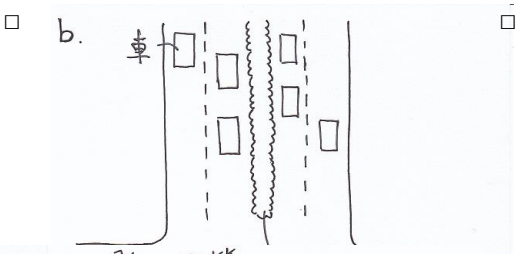
2a. If yes, where would you prefer to see more trees and plants? (Please check all that apply.)
   - □ a. Parks and gardens
   - □ b. Public plazas
   - □ c. Alleys
   - □ d. Roads and streets
   - □ e. Water's edge
   - □ f. Cemeteries

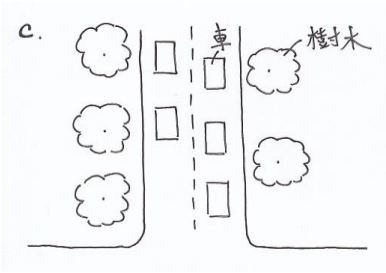
The following questions 3-7 are in Likert-scale. 1 point is strongly dislike/disagree; 5 points is strongly like/agree.

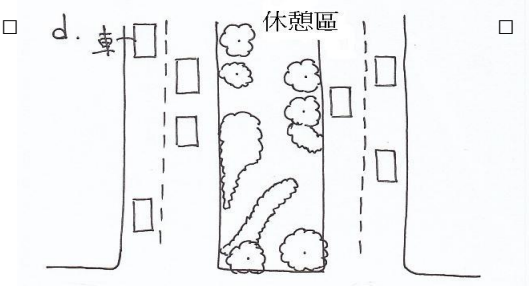
3. Do you like the current urban greening in Macao?	1	2	3	4	5
4. Do you like the methods of urban greening in Macao?	1	2	3	4	5
5. Compare to the past, you prefer the current urban greening.	1	2	3	4	5
6. Compare to the past, the environment is improved now.	1	2	3	4	5
7. Compare to the past, you would stay outside for a longer time.	1	2	3	4	5

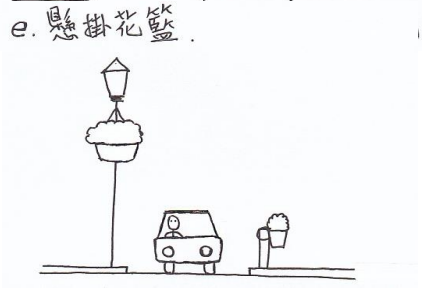
8. Which streetscape do you prefer? (Please check all that apply.)

□ 

□ 

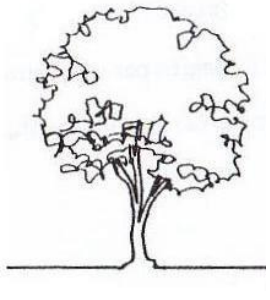
□ 

□ 

□ 

9. If the government provided the following plants for you to choose, what would you like for the parks and recreational areas? (Please check all that apply.)

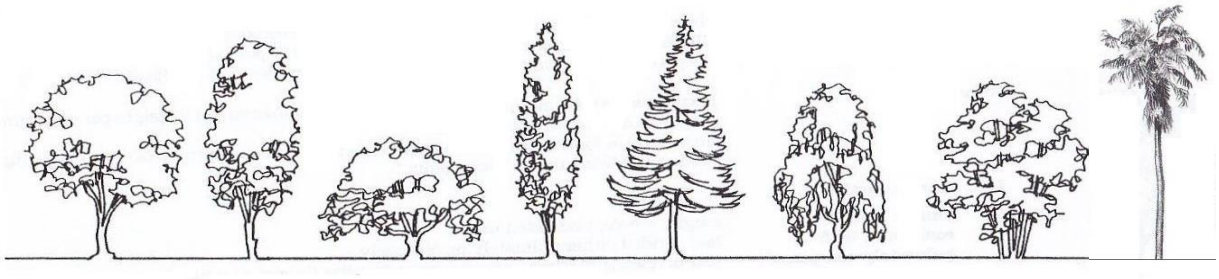
- ☐ a. Deciduous trees
- ☐ b. Evergreen trees
- ☐ c. Shrubs
- ☐ d. Flowering plants
- ☐ e. Non-flowering plants



Trees are usually tall (more than 5 meters) and with one main stem.

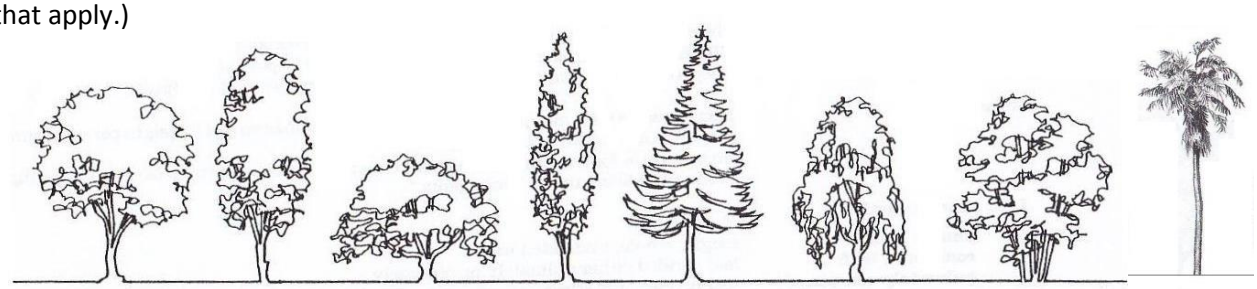
Shrubs are usually short (less than 5 meters) and with multiple stems.

10. If planting trees in parks and recreational areas, which tree shape(s) do you like? (Please check all that apply.)



a.	b.	c.	d.	e.	f.	g.	h.
☐	☐	☐	☐	☐	☐	☐	☐

11. If planting trees in parks and recreational areas, which tree shape(s) do you dislike? (Please check all that apply.)

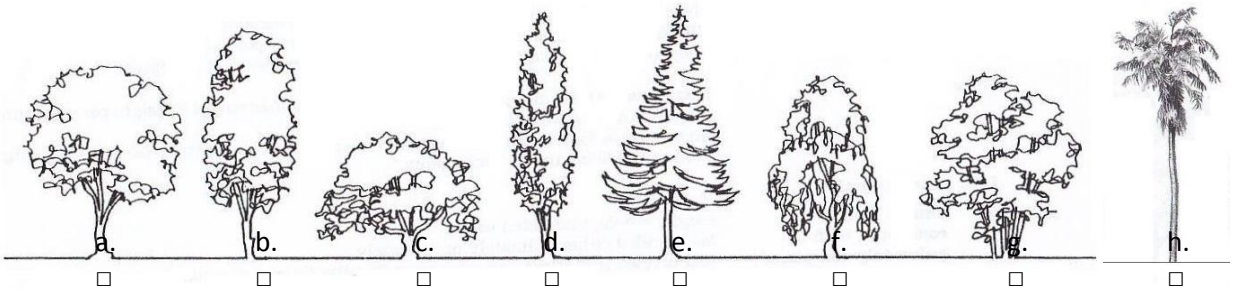


a. ☐ b. ☐ c. ☐ d. ☐ e. ☐ f. ☐ g. ☐ h. ☐

12. If the government provided the following plants for you to choose, what would you like for the roads and streets? (Please check all that apply.)

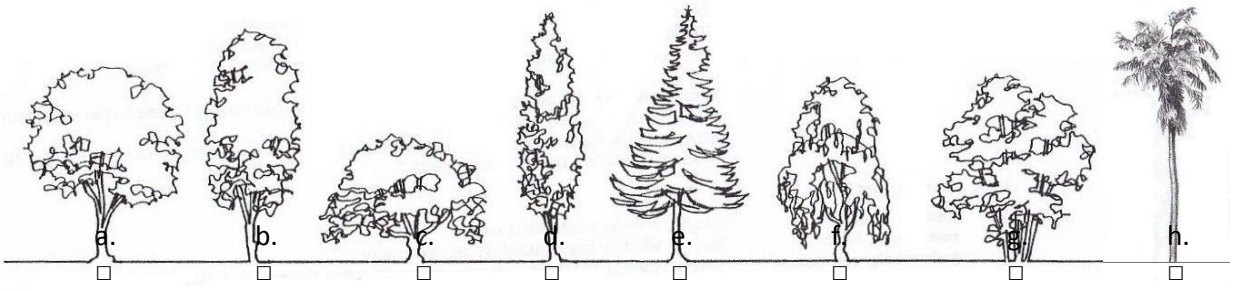
- ☐ a. Deciduous trees
- ☐ b. Evergreen trees
- ☐ c. Shrubs
- ☐ d. Flowering plants
- ☐ e. Non-flowering plants

13. If planting trees in roads and streets, which tree shape(s) do you like? (Please check all that apply.)



a. ☐ b. ☐ c. ☐ d. ☐ e. ☐ f. ☐ g. ☐ h. ☐

14. If planting trees in roads and streets, which tree shape(s) do you dislike? (Please check all that apply.)



a. ☐ b. ☐ c. ☐ d. ☐ e. ☐ f. ☐ g. ☐ h. ☐

15. Do you think there is enough green space in your neighborhood?

- ☐ Yes
- ☐ No

16.	Do you like the following greening methods? (Please answer each sub-question. If you answer 'No' for any of them, please answer the corresponding sub-question(s) of question 17 and 18.)	Yes	No
	16a. Trees		
	16b. Shrubs		
	16c. Vertical greening (such as the vines on the fences)		
	16d. Hanging flower pots		
	16e. flower pots on ground		

17.	Reason(s) that you do not like the greening method(s) mentioned in question 16. (Please check all that apply.)	
	17a. Trees	□ i. Block the pathways □ ii. Block the doors and/or windows □ iii. Allergy □ iv. Pile up rubbish or cigarette butts □ v. Pest □ vi. Chance of falling down (esp. during typhoon)
	17b. Shrubs	□ i. Block the pathways □ ii. Block the doors and/or windows □ iii. Allergy □ iv. Pile up rubbish or cigarette butts □ v. Pest
	17c. Vertical greening	□ i. Block the pathways □ ii. Block the doors and/or windows □ iii. Allergy □ iv. Pile up rubbish or cigarette butts □ v. Pest
	17d. Hanging flower pots	□ i. Block the pathways □ ii. Block the doors and/or windows □ iii. Allergy □ iv. Pile up rubbish or cigarette butts □ v. Pest □ vi. Chance of falling down (esp. during typhoon)
	17e. flower pots on ground	□ i. Block the pathways □ ii. Block the doors and/or windows □ iii. Allergy □ iv. Pile up rubbish or cigarette butts □ v. Pest

18.	How to improve the problems mentioned in question 17? (Please check all that apply.)	
	18a. Trees	□ i. Do not use this method □ ii. Use another method □ iii. Frequent maintenance □ iv. Frequent checking □ v. Frequent cleaning □ vi. Reinforcement before typhoon season
	18b. Shrubs	□ i. Do not use this method □ ii. Use another method □ iii. Frequent maintenance □ iv. Frequent checking □ v. Frequent cleaning
	18c. Vertical greening	□ i. Do not use this method □ ii. Use another method □ iii. Frequent maintenance □ iv. Frequent checking □ v. Frequent cleaning
	18d. Hanging flower pots	□ i. Do not use this method □ ii. Use another method □ iii. Frequent maintenance □ iv. Frequent checking □ v. Frequent cleaning □ vi. Put them down before typhoon
	18e. flower pots on ground	□ i. Do not use this method □ ii. Use another method □ iii. Frequent maintenance □ iv. Frequent checking □ v. Frequent cleaning

19. Ideas for improving Macao's urban forestry:

Section II

1.	You are:			
	□ a. Residents	□ b. Non-resident		
2.	Gender:			
	□ a. Male	□ b. Female		
3.	Age:			
	□ a. 0-17	□ b. 18-45	□ c. 46-64	□ d. 65 or up
4.	Highest educational level			
	□ a. primary school graduate		□ b. high school graduate	
	□ c. Bachelor degree		□ d. Master degree or higher	
5.	Living area: (Please refer to the map below.)			
	□ a. Northeast area of Macao Peninsula		□ b. Northwest area of Macao Peninsula	
	□ c. Central area of Macao Peninsula		□ d. West area of Macao Peninsula	
	□ e. Southeast area of Macao Peninsula		□ f. Southwest area of Macao Peninsula	
	□ g. Taipa Island		□ h. Coloane Island	
	□ i. Don't know, street name: _____			
6.	How much time per week would you spend outdoors?			
	□ a. 0-5 hours	□ b. 5-10 hours	□ c. 10-20 hours	□ d. 20 hours or more
7.	How much time per week would you spend in parks and recreational areas?			
	□ a. 0-5 hours	□ b. 5-10 hours	□ c. 10-20 hours	□ d. 20 hours or more

The information above will not be presented to the public. All information would only be used for this survey only.