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PLANNING STEPS OF URBAN GREEN INFRASTRUCTURE IN EXISTING CITIES

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ABSTRACT

The negative impacts of climate change have spread widely and calls increased toward finding smarter strategies that can support both climate change adaptation and mitigation. Urban Green Infrastructure (UGI) is considered a certain type of such strategies. The literature review indicates a lack of knowledge regarding the planning steps of UGI in existing cities. In addition, the comparison between the studies that tackle the subject point out that there are differences between the definition and sequence of these steps. The current research aims to find out the optimal planning steps of UGI and the most acceptable sequence of the planning process for climate change smart adaptation in existing cities. By using the methodology of "learning by doing", the research seeks to conclude these steps from the world's real practices. A cross-case analysis was conducted between four main practices to define the relationship between their planning steps and determine their similarities and differences. The cross-analysis revealed that the practices almost followed similar processes but with different definitions and sequences of planning steps. Based on the intersections between practices and by following the planning logic, the optimal definition and sequence of UGI planning were extracted and outlined in "seven planning steps". These steps include: providing the precise identification of the impact, identifying the higher-risk neighborhoods, collecting data about the existing conditions, protecting and enhancing existing green and blue elements, adding new UGI assets, drawing the results, and finally calculating the UGI effectiveness. This set of steps can guide the whole process of UGI planning and ensure the maximum benefits of employing it in existing cities to achieve the climate change smart adaptation.

Keywords: climate change, green infrastructure, smart planning, adaptation, mitigation, existing cities

INTRODUCTION

There is an unprecedented change in the global climate system. Related studies confirmed that human modern activities are the main cause of this change. The atmosphere, ocean, and land warm decade after decade. In the period between (2020–2021), the average temperature of the earth's surface increased by about 0.99°C higher than it has been between 1850–1900, which refers to the pre-industrial period. In general,

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land witnesses a more warming pattern than the other regions (IPCC, 2021). Over time, climate change caused many species' extinction, large people migration, and substantial weather changes. So, it is not a newly appeared phenomenon. The new facet represents in its speed which dramatically increases to surpass the earth's natural ability to absorb or cope (USNAS, 2014). This causes many devastating impacts such as extreme weather (e.g., hurricanes and cyclones, heatwaves, sand and dust storms, wildfire and cold spells, etc.), floods, precipitation change, droughts, temperature rise, and rise in sea level (UNFCCC, 2019). This leads to significant losses representing water scarcity, agricultural land reduction, health degradation, deforestation, etc. (UNFCCC, 2019).

The impacts of global climate change are mainly concentrated in cities where more than 50% of the earth's inhabitants settle and live (Hunt & Watkiss, 2011). There is an interactive relationship between urbanized areas and climate change. From a certain side, cities are the most diagnosed cause of many environmental problems. The impacts of such problems extend beyond the cities' geographical boundaries and directly contribute to the accumulation of global climate change. On the other side, cities are the most vulnerable areas to the negative impacts of this change (Salata & Yiannakou, 2016).

In the first human attempts to counter climate change, the focus was intensively directed toward the concept of "adaptation" which enables societies to deal with climate change's impacts. After a while, great awareness has risen regarding the uselessness of addressing the impacts without addressing the causes. Accordingly, "mitigation" which enables societies to reduce the climate change's causes, acquired the same importance as adaptation in the field of climate change control. Both of them are considered two sides of the same coin of climate change control (Davoudi, 2009; Janetos, 2007). The current research's attention is directed toward finding a win-win approach of climate change mitigation and adaptation. This approach will be named a smart climate change adaptation (CCSA). In the present research. CCSA can be defined as (the process and its results of depending on the appropriate adjustments in the human and natural systems to cope and reduce climate change impacts and causes simultaneously).

For urban planners and designers, achieving synergies between climate change adaptation and mitigation is not an easy mission. That is because of the small number of integrated strategies that can assure this approach (Davoudi, 2009). A review of the related literature revealed that Urban Green Infrastructure (UGI) represents a certain type of CCSA. That is because UGI services support both adaptation and mitigation functions (Samora-Arvela et al., 2017; Abdulateef & Al-Alwan, 2022). In countering the temperature rise, for example, the adaptive role of UGI represents in reducing air and surface temperature via two main processes of evapotranspiration and shading. On the other hand, the mitigative role of UGI represents by reducing greenhouse gases (GHG) emission and their concentrations within the biosphere via the carbon storage and sequestration (Demuzere et al., 2014).

UGI can be defined as "the networks of green and blue spaces in urban areas, designed and managed to deliver a wide range of ecosystem services and other benefits at all spatial scales" (Hansen et al., 2017a). In existing cities, UGI is usually challenged by many barriers such as the built-up layers, the shortage of traditional green spaces, etc. Accordingly, the current research aims to provide knowledge about the planning steps of UGI for CCSA in existing cities. The purpose of this paper is reviewing and analyzing some good practices of UGI planning in existing cities. That is to offer a clear knowledge about the most adopted planning steps in these practices which can be adopted in other cities around the world.

LITERATURE REVIEW

Reviewed studies will be presented concerning the research's basic field which is UGI planning steps in existing cities. In 2013, Firehock conducted a related study that explained six steps of UGI planning (Firehock, 2013). These steps include: setting goals, reviewing data, drawing an assets map, assessing risks,

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determining opportunities, and implementing them. The first step involves a clear definition of what the community values. Reviewing data (step 2) includes the collecting of all available and required data about the identified values. Following this step, all valued assets should be clearly mapped (step 3). Assessing risks (step 4) aims to clearly define the assets which are vulnerable to climatic risk. The fifth step "determining opportunities" involves the identification of the at-risk assets that should be protected and restored. At the final step of Firehock's suggested planning approach, opportunities should be implemented according to daily and long-term maps (step 6).

Landscape Institute (LI) in London city suggested another series of UGI planning steps which are: partnering and vision, contextual review, information audit and resource mapping, needs and opportunities valuing, detailing the planned interventions, implementation, management and maintenance (LI, 2013). Following such steps can ensure the provision of different ecological, social, and economic benefits. Another study conducted by Hansen et al. assured that UGI planning can be conducted according to a different set of steps which represent in: setting goals, identifying the suitable sites, following principles of planning, defining the qualification requirements, making targeted use of instruments, working together for green infrastructure, securing and developing the green infrastructure (Hansen et al., 2017a). This approach sheds the light on the importance of community cooperation in all planning stages.

In 2018, Ruskule et al. revealed that to counter water scarcity and achieve successful management of lowland rivers, UGI should be planned according to three main steps (Ruskule et al., 2018). These steps comprise mapping and assessing current UGI, assessing UGI status and identification of problems, and developing UGI improvement scenarios. The study also includes the testing of the proposed planning methodology at four different planning levels.

The United Kingdom Green Building Council reported that to have an efficient network of UGI, the planning steps should start by having a real corporation with the stakeholders and all collaborative sectors (UKGBC, 2020). Second and third steps should involve the active experts' participation, and the thorough connecting of the landscape policy to the planning framework. The following steps should include assessing the UGI current elements, developing a UGI plan, implementing and managing the UGI plan, and putting the UGI strategy at the organizational scale.

The thorough review of the above-mentioned studies reveals that, although there is a comparative agreement on following some steps of UGI planning, such as drawing a base UGI map and assessing its values, there are also clear differences concerning other steps, such as defining the stakeholders and the use of UGI planning principles. Another difference between the reviewed studies can be noticed as there are cross-studies steps, such as drawing UGI assets map and establishing wide coordination, which appears in a different sequence in each approach.

Previous studies provided knowledge about the steps of general UGI planning as they proposed it for different aims such as conserving natural resources, improving people's health, supporting cultural identity, finding a vibrant community, etc. Adapting UGI for climate change adaptation was also mentioned but without detailing its requirements and challenges.

Therefore, it can be concluded that knowledge concerning the planning steps of UGI as a strategy for climate change smart adaptation is not sufficiently clear. Although there is some agreement concerning some steps of UGI planning such as (drawing a base UGI map and assessing its values), there is also a difference in defining these steps and their sequence. So, there is no agreed-upon theoretical knowledge of planning UGI in existing cities. Accordingly, there is a lack of knowledge concerning the planning aspects of UGI as a strategy for climate change smart adaptation in existing cities. More researches addressing this aspect are required.

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METHODOLOGY

In the Cambridge English dictionary, the word "Step" refers to "one of the things that you do to achieve something" (Cambridge Dictionary, 2020). Hence, following some compatible steps will assist in achieving the pre-defined aims of the planning process. To identify the steps of UGI planning in exiting cities for CCSA, some good cases of UGI planning will be reviewed and analyzed. This method is called "Learning by doing" or "adaptive planning". Learning by doing or learning by practices is a scientific landscape approach that aims to construct the planning process on the available knowledge that is embodied in real practices. This method can provide practical evidence of the usefulness of any landscape intervention (Ahern, 2007). By reviewing some related studies, it was found that the methodology of "learning by doing" was previously used to find some results about UGI (Mell, 2010; Lennon & Scot, 2014; Grădinaru & Hersperger, 2018). So, it is a reliable research method. By using this method, the following stages were proposed to achieve the research aim:

– Stage 1: selecting some practices (case studies) of UGI planning in existing cities for CCSA.
– Stage 2: providing a general overview of each case study with an intentional focus on the city's geographical location, configuration, and climate conditions.
– Stage 3: exploring the impacts of climate change on the city environment and the adopted UGI strategy. This stage presents a clear definition of the steps of the UGI planning process in each case study.
– Stage 4: conducting a cross-analysis between the steps of UGI planning of the case studies.
– Stage 5: extracting the planning steps of UGI for CCSA in existing cities.

The process of selecting the case studies was based on some criteria that were set up to well direct the research towards achieving its aim. These criteria are summarized in the following:

– All selected case studies are existing cities that employ UGI for CCSA such as stormwater management or urban heat island control.
– All selected case studies are existing cities that employ UGI with a clear set of planning steps.

Around the world, there are many cities that employed UGI networks, such as: Malmo; Sweden, Milan; Italy, Edinburgh; Scotland, New York; USA, etc. (Hansen et al., 2017b). Accordingly, four main cities which are fully compatible with the previous criteria are selected namely: Philadelphia; USA, Melbourne; Australia, Tucson; USA, and Singapore; Southeast Asia.

1. Philadelphia, USA

Philadelphia is located at 40°0′N and 75°8′W towards the eastern coast of the country. It is the largest city in Pennsylvania (U.S. Census Bureau, 2016; Focht, 2013). Until 2018, Philadelphia was occupied by about 1,584,138 people with a density of more than 4500 people/ km². The total city area is about 369.62 km², of which 347.52 km² is land and 22.09 km², or 6%, is water. The water ratio includes rivers, lakes, parks, and creeks (United States Census Bureau, 2018). According to Köppen climate classification, the city of Philadelphia has a temperate humid subtropical climate (symbolized as Köppen Cfa). Relatively high temperatures and distributed rainfall throughout the year seasons are the main characteristics of this climatic group (Weatherbase, 2020).

In 2009, Green infrastructure was launched as a basic strategy of the Green city – Clean water program, which was identified by Philadelphia water department (PWD) to control the overflow of the combined sewer system. In Philadelphia, the combined sewer system serves about 48% of the city. In the case of moderate or heavy rainfall, the combined sewer system reaches its peak capacity and directly discharges water into the city water bodies, causing significant water pollution. UGI was employed to control this case of the combined sewer overflow (PWD, 2011). Within Green city – Clean water program, green infrastructure is defined as "a group of soil-water-plants systems that delay and intercept the stormwater flow". They absorb, allow filtration, evaporate, and delay the water release into the combined sewer system (PWD, 2011).

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As a sustainable stormwater strategy, UGI is mainly planned and designed to reduce surface runoff and prevent floods. Other related services of UGI are ranking in second place, enhancing the effectiveness of the strategy. UGI provides a natural ability for onsite rainwater capturing and treating by providing more natural filtration. This leads to reduce the surface runoff and store it as underground water. Simultaneously, it causes a minimization in the volume of the greywater, as well as the pressure on the sanitation system and water treatment plants (Copeland, 2014).

Green city – Clean water program takes place in three parallel paths which combine both private and public sectors (PWD, 2016). The program of public investment or what is named "capital projects" involves the incorporation of UGI assets in the city ownership location (PWD, 2018). The planning phase of UGI capital projects was directed to define and prioritize the opportunities of having green and blue assets in a city-owned and private property where owners have an interest in stormwater management. The planning process had a clear workflow which consists of the following steps (PWD, 2016, 2018):

– Step 1: project initiation: this step included providing a clear definition of the study area. It involved the identification of the project's spatial scope, schedule, and budget. Within this step, hard efforts were conducted to review and understand the available data about the study area such as the GIS maps or any other type of format.
– Step 2: existing conditions evaluation: represented in exploring the physical conditions of the study area and surveying the current planning initiatives. The study area conditions such as land use, vacancy, tree-covered area, major public parcels such as churches, schools, transportation facilities, etc. were identified in a set of separate detail layers. All current and future planning initiatives were also reviewed. That was to define UGI future opportunities and barriers.
– Step 3: drainage area delineation: producing maps of stormwater drainage patterns within the city represented an essential procedure of UGI planning in Philadelphia. The rainwater flow within the city's parcels and streets was thoroughly analyzed and mapped. To have a precise drainage delineation, all influencing factors such as the location topology, site configuration, and inlets positions were considered in this analysis.
– Step 4: feasibility analysis: this step aimed to identify the suitable physical locations of UGI projects within the study area. The potentiality of locations to have UGI projects was divided into three levels of high, medium, and low according to the site exiting constraints. A feasibility analysis was conducted first at the streets level and followed at the parcels level. The analysis showed that some drainage areas can be managed by both streets and parcels UGI projects.
– Step 5: alternative selection: many potential locations for UGI projects were identified from the previous step of feasibility analysis. To select the most suitable alternatives, especially in sites that can be managed by both streets and parcels UGI, PWD plan highlighted some criteria which facilitated the selection process.
– Step 6: Packaging: this stage included the grouping of the proposed UGI locations into packages of about 10-15 assets which were similar and spatially close to each other. This assisted in saving cost, work and time.

2. Melbourne, Australia

Melbourne or Greater Melbourne is located at 37°49'S and 144°58'E, within the state of Victoria and on the southern shore of south-eastern Australia (Australian Bureau of Statistics, 2011). The total city area is about 9992.5 km^2, representing the metropolitan area with 31 municipalities (Australian Bureau of Statistics, 2016). Melbourne is widely known as "Australia's garden city" as it has a unique network of parks and gardens. According to Köppen climate classification, Melbourne has a temperate oceanic climate (symbolized as Köppen Cfb) with moderate winters and warm to hot summers (Tapper & Tapper, 1996). Melbourne is located within the southern

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hemisphere which is recognized for having reverse seasons than those in North America, Europe, and most of Asia. So, changes of seasons in Melbourne are known for starting late. January and February present high summer months, while May, June, July, and August represent the winter months. For rainfall, December has the most amount of about 2.5mm, while February has the least about 1.6" (Melbourne, 2020; Australian Bureau of Meteorology, 2020).

UGI strategy was proposed in Melbourne to control urban heat island (UHI) and cool the microclimate in its different urban spaces (Bosomworth et al., 2013). Melbourne's strategy refers to UGI as a "connected network of natural and human-added vegetation which includes parks, gardens, trees, green walls, and roofs, etc." (Bosomworth et al., 2013). Some basic steps were identified to guide the planning of UGI strategy in Melbourne. These steps were summarized in the following (Norton, et al., 2014):

– Step 1: identify priority areas: these areas represented those of high exposure and vulnerability. Identifying exposure areas depended on a deep analysis of Melbourne UHI. That was to identify the regions of the higher and lower temperature and the thermal variation within the single region. Areas that had intensive pedestrian activities such as the city center were recognized and put first as they had higher exposure to UHI. After that, identifying vulnerability assessment was conducted.
– Step 2: maximize the cooling effect of existing UGI: this aimed to increase the plant's health by, for example, irrigation which would improve the plant's ability to lower temperature and provide shade. To overcome the crisis of water scarcity through the hot seasons, recycled water from sewage systems and the rainwater of the storm infrastructure were used as alternative resources of water. Increasing the built surface permeability was also adopted to allow for more rainwater infiltration. In addition to that, a mix of native and deciduous plants was selected to offer natural adaptive vegetation.
– Step 3: prioritize streets to have UGI: priority points to have UGI are usually represented in car parking, street intersections, and canyons that have intensive exposure to UHI.
– Step 4: analyze and select UGI assets: this step included the process of selecting and designing the most appropriate UGI assets. At the neighborhood level, open green spaces were proposed when there were available open areas. At the canyon scale, trees were adopted where there was enough space in the street. On the other hand, green walls and roofs were proposed for the high built-up areas.

3. Tucson, USA

Tucson is located at 32°13′N 110°55′W in the southwest region of USA. It is one of the biggest cities in the state of Arizona. The city's total area is about 588.65 km². Tucson lies on an alluvial plain in the Sonoran Desert. It is surrounded by five small ranges of mountains (City of Tucson, 2011). According to Köppen climate classification, Tucson has a hot semi-arid climate (symbolized as Köppen BSh) with two main seasons of moderate winter and very hot summer (CLIMATE-DATA.ORG, 2020).

The Southwestern U.S., where Tucson is located, is a broad desert characterized by a hot-dry climate with long months of drought waves. These waves are usually interspersed with heavy rainfall which can cause severe floods. This high-intensive rainfall usually occurs in the form of short-duration thunderstorms which happens in the summer season from July to September and causes severe floods (City of Tucson and Pima county, 2015). Heat stress forms another real climatic issue in the state of Arizona which witnessed the highest national rate of weather-related deaths since 1986 (Ogata, 2014).

Tucson strategy refers to UGI as constructed elements which employ natural systems to provide multiple benefits (WMG, 2015). Tucson's UGI strategy depends on the concept of "stormwater harvesting" at the neighborhood scale. At the same time, UGI can significantly contribute in lowering the city UHI phenomenon (WMG, 2017). Concerning UGI planning in Tucson, some basic steps were identified as a core structure of Tucson UGI strategy. These steps were summarized in the following (WMG, 2017):

– Step 1: identify the watershed: this step was crucial when UGI strategy was adopted for stormwater

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control. The step included determining how water flows and where it collects in the city neighborhood. Areas, where rainwater is usually collected, were carefully mapped and defined.
– Step 2: identify the suitable groundwater recharge areas: these areas represented points where the groundwater level is shallow. Points with lower groundwater levels represented the most ideal points to direct the water flow and have new UGI assets.
– Step 3: identify the vital routes: this step aimed to identify routes that are heavily used by pedestrians and cyclists. The step also included the identification of gathering spaces where people usually meet and recreate.
– Step 4: identify the potential opportunities to have UGI: these opportunities represented the right-of-way, vacant lots, parking, public schools, other infrastructure, etc.
– Step 5: identify the best opportunities: this step included a trade-off comparison between potential opportunities in terms of flood control capacity and cost. That was to define the most appropriate ones.

Accordingly, many maps have resulted. When these maps were overlaid, the priority places where UGI was needed and appropriate became obvious. The most appropriate spots to have UGI appeared where these maps intersected and overlapped (WMG, 2017).

4. Singapore, Southeast Asia

Singapore is an island city-state in Southeast Asia, with an area of about 719 km^2. It has a tropical and coastal climate characterized by high temperature, humidity, and rainfall intensity distributed throughout the year. On average, rain falls about 178 days in the year (Meteorological Service Singapore, 2021). Storms come usually in the form of monsoon surges. Singapore constitutes flat areas with low-lying pockets on the eastern and southern coasts. Having such geography increases the flood risks, particularly when intensive rainfall concurs with high tide movement (PUB, 2013). Despite the land scarcity, the country witnessed a rapid urbanization process over the past few decades and became the third most densely populated country in the world (UN, 2016). Construction of the high-density development leads to an increase in impervious surfaces and a reduction in the green spaces. Accordingly, the site's natural ability to filtrate and absorb the stormwater was reduced significantly. This leads to an increase in the runoff peak and causes terrible floods (PUB, 2013). In addition to causing floods, the resulted runoff forms a major source of water bodies' pollution (Liao, 2019). Unremitting efforts were made in Singapore to find a smart strategy that can prevent the risk and benefit of each drop of rain to ensure water security (Sen, 2014).

In 2016, a program of Active, Beautiful, Clean (ABC) Waters was launched by Singapore's national water agency (Public Utilities Board – PUB) (PUB, 2018). ABC program follows a set of earlier water-vegetated plans which were adopted to enhance Singapore's scene. The outcomes of these plans put the foundations for ABC program (CLC, 2017). Originally, Singapore negated the risk of flooding by the construction of many reservoirs, concretized rivers, canals, and drains. These elements were planned as pathways to convey stormwater and prevent floods. They formed a network of highly used, centralized, controlled, and unattractive places which remained empty and dismal in the dry seasons (Liao, 2019). From this backdrop, ABC instructions regarding stormwater management emerged. The instructions assured the importance of inversing the physical and social image of the existed water elements from drainage channels and tanks to attractive community spaces (PUB, 2018). ABC program also assured that treating stormwater via the original water canals (pathways) is not enough as water should also be treated in spaces where stormwater is generated (sources) and spaces where stormwater may affect other infrastructure and cause risks (receptors) (PUB, 2018). The source-pathway-receptor approach was adopted to mitigate runoff at sources, expand pathways' capacity to convey runoff, and add flood protection at receptors (Lim & Lu, 2016). In a high-density city such as Singapore, planning UGI is significantly challenged by many

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constraints. The most effective constraint is land scarcity. ABC program proved its success to overcome such an issue (Liao, 2019).

ABC program involved many subprograms and applications deeply related to each other. In the current research, an intentional focus will be directed to those parts of the sustainable stormwater management of Singapore that thoroughly discussed UGI planning process. Depending on studies that explored the sustainable stormwater management in Singapore, the planning steps of UGI strategy can be presented as follows:

- Step 1: maximize the benefits of the existing pathways: an essential step of UGI planning in Singapore practice was protecting and enhancing the water pathways. This planning was built upon qualifying what the site had of pathways considering them as the starting point to have a strong and unique UGI network. Dealing with the existing assets is not limited on enhancing the environmental functions of flood reduction only, but also to adding a strong social role to these assets to be a part of everyday life. That is to integrate people with water and the environment (PUB, 2018).
- Step 2: conduct a risk assessment: UGI planning in Singapore practices was based on assessing the flood risk which mainly depends on the site lying and the development type. Singapore strategy referred to the necessity of employing UGI in the eastern and southern coasts of the city as they are low-lying areas and are more vulnerable to flood risk (PUB, 2013). Such areas have the priority to have UGI strategy. The classification of locations into sources, pathways, and receptors also depends on defining the on-site type of risk (PUB, 2018).
- Step 3: add new UGI assets in sources locations: ABC program involved a proactive implementation of UGI assets or what was called (ABC Water design features) (Sen, 2014). To prevent floods sustainably, ABC program sought to employ green elements as a nature-based solution to delay, filtrate and store the runoff (Liao, 2019). The elements store stormwater temporarily and release it slowly to the constructed drainage system. Reducing peak runoff at sources locations depends mainly on injecting different assets of UGI. The injection process implied some certain sub-steps which are:
  - Select the appropriate sites of the new UGI assets: ABC program involved a master plan approach at the country scale. This master plan identified precisely the sites of all UGI projects. The selection process of the appropriate sites was based on five main criteria which are: concerning the sites' potentials that contribute to water quality improvement, incorporation of educational activities benefiting the community, ease of implementation, and the integration with an existing development project or park (Liao, 2019).
  - Define the site's existing and proposed runoff conditions: data was collected about the site area; the potential peak inflow and the expected time to reach this peak. In this sub-step, the allowable peak outflow of the site and the entailed time were also defined. That depended on PUB guidelines of flood reduction (PUB, 2013).
  - Determine and design new UGI assets: to achieve the allowable peak outflow and reduce time to peak, appropriate UGI assets were selected. PUB presented specific guidance for selecting, sizing, implementing, and maintenance of the ABC Water features. Defining the suitable UGI was based on many considerations such as space availability, topography, site obstructions, maintenance, and safety (PUB, 2013).

DISCUSSION

To find out the most adopted definition and sequence of the planning steps of UGI, a cross-analysis between practices will be conducted. To achieve this, the planning step of UGI in each practice will be symbolized (Fig. 1). Each step will have a symbol of a letter and number such as P1 and M2. The letter refers to the city name, for example, P for Philadelphia and M for Melbourne, T for Tucson, and S for Singapore. The number refers to the step sequence, for example, 1 for the first step and 2 for the

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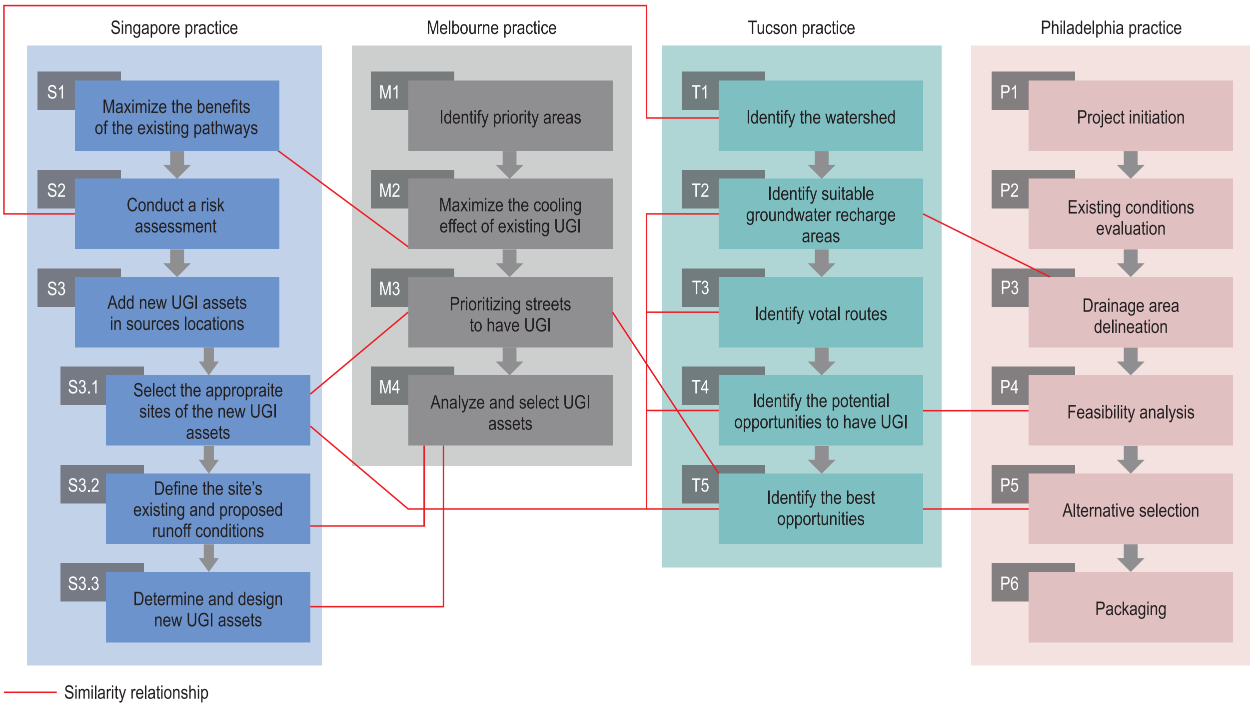

Fig. 1. Cross analysis of the case studies
Source: own preparation.

second step, and so on. The cross-analysis between the planning steps of the four practices represents the following points:

- Step S1 "maximize the benefits of the existing pathways" and M2 "maximize the cooling effect of existing UGI" referred to the same process of protecting and enhancing the existing water and vegetated elements and qualifying them as UGI assets.
- Step S2 "conduct a risk assessment", P3 "drainage area delineation" and T1 "identify the watershed" referred to almost the same process of drawing and understanding the potential risk of climate change impact and its pattern in the study area.
- Step T4 "identify the potential opportunities to have UGI" and P4 "feasibility analysis" aimed to define the available locations for adding the potential UGI in the study area.
- Step S3.1 "selecting the appropriate sites of the new UGI assets", M3 "prioritize streets to have UGI", T5 "identify the best opportunities", and P5 "alternative selection" involved the same process of adopting some priority local criteria to select the most suitable locations for adding new UGI assets.
- Step M4 "analyze and select UGI assets" includes the processes conducted in step S3.2 and S3.3. As they both involved the selection, design, sizing and the definition of other related requirements of the new UGI assets.
- In Tucson practice, many detailed steps (T2 to T5) were followed to define the most suitable locations for adding new UGI assets according to some priority criteria. While, in Singapore practice, the same process was conducted in a single one-step (S3.1) which involved many sub-steps. That means both practices conducted the same process but under different labels.
- Despite not being mentioned as a basic planning step except in P2, (existing conditions evaluation) was an implicit process in all case studies.

Comparing similar steps with each other reveals that there are some detailed differences between them. M2 and S1, for example, refer to the same process of providing more ecosystem services via protecting

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and enhancing the existing UGI assets. In Melbourne, plans were directed to increase the regulation services that relate to the cooling of the environment. While in Singapore, measures were adopted to achieve multifunctionality. Some detailed differences can also be found between M3, T3, and S3.1 which aim basically to define the appropriate location of new UGI assets. These differences relate to the variety of selection criteria. In Melbourne and Tucson practice, the selection process depends on the site's potential exposure to the climate change risk. While in Singapore practice, the selection process was based on the site's potential to contribute in water quality improvement, incorporating educational activities, benefiting the community, etc.

EXTRACTION THE PLANNING STEPS OF URBAN GREEN INFRASTRUCTURE

The cross-analysis between the four case studies shows that although the planning processes of UGI are widely similar in all case studies, they were employed under different steps' definitions and sequences. According to the previous discussion, the optimal definition and sequence of the planning steps of UGI in existing cities for CCSA can be extracted as a set of "Seven basic steps".

These steps can answer some main questions of why, where, and what UGI assets should be used. The extracted seven basic steps of UGI planning are described as follows (Fig. 2):

- Step 1: provide precise identification of the impact: this step involves conducting a detailed identification of the climate change impact for which UGI strategy will be adopted. This identification should include the impact definition, intensity, and causes. If it is possible, projections for the impact of future behavior should also be conducted. This is to consider any potential risks.
- Step 2: identify the higher-risk neighborhoods: this step aims to highlight the higher priority neighborhoods to have UGI. The identifying risk depends on overlapping two factors of impact intensity (the result of step 1) and local vulnerability. Detailing vulnerability depends on the targeted vulnerable sector whether it is people, buildings, or local ecosystems.
- Step 3: collect data about the existing conditions: this step includes collecting data about the physical conditions of the higher priority neighborhoods. This data includes neighborhood location, total area, boundaries, urban geometry analysis, land use analysis, buildings ownership, local related laws and regulations, current and future development projects, local barriers, etc. Many of these parameters should be presented in separate layers and tables.
- Step 4: protect and enhance the existing green and blue elements: this step includes two main processes: mapping the on-site green assets and proposing suitable policies for them. It includes the adoption of a certain policy of protecting, enhancing, and restoring the place's UGI assets. That depends on the full understanding of the previous, current, and potential status of these assets. This step aims to protect and restore what has already functioned well and uplift the poor. Qualifying the existing UGI assets to achieve multifunctionality should be considered the ultimate goal of enhancing and restoring policies. Accordingly, measures should be adopted not just to strengthen the UGI role as a strategy of climate change adaptation but also as a well-being enhancement and economy support strategy.
- Step 5: add new UGI assets: this step involves many sub-steps such as identifying the priority locations (priority streets and parcels), finding available sites for potential UGI in priority locations (availability and feasibility analysis), propose UGI assets for each type of available sites, select the most effective potential UGI assets (alternative selection) and packaging the selected UGI assets in certain similar and closer groups.
- Step 6: draw the result: this step refers to the drawing of on-site and new UGI assets in a single basic map. That is to have a complete image of UGI and its environmental effectiveness. This step is also essential in diagnosing the points of weakness in the network planning and proposing suitable solutions to them.

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– Step 7: calculate UGI effectiveness: calculate the climatic effect of the proposed UGI strategy is an essential step in its planning. That is because it allows measuring the validity of the proposed strategy. This measure can be conducted by using some simulation computer programs such as RayMan and ENVI-met (RayMan, 2022; ENVI-MET, 2022).

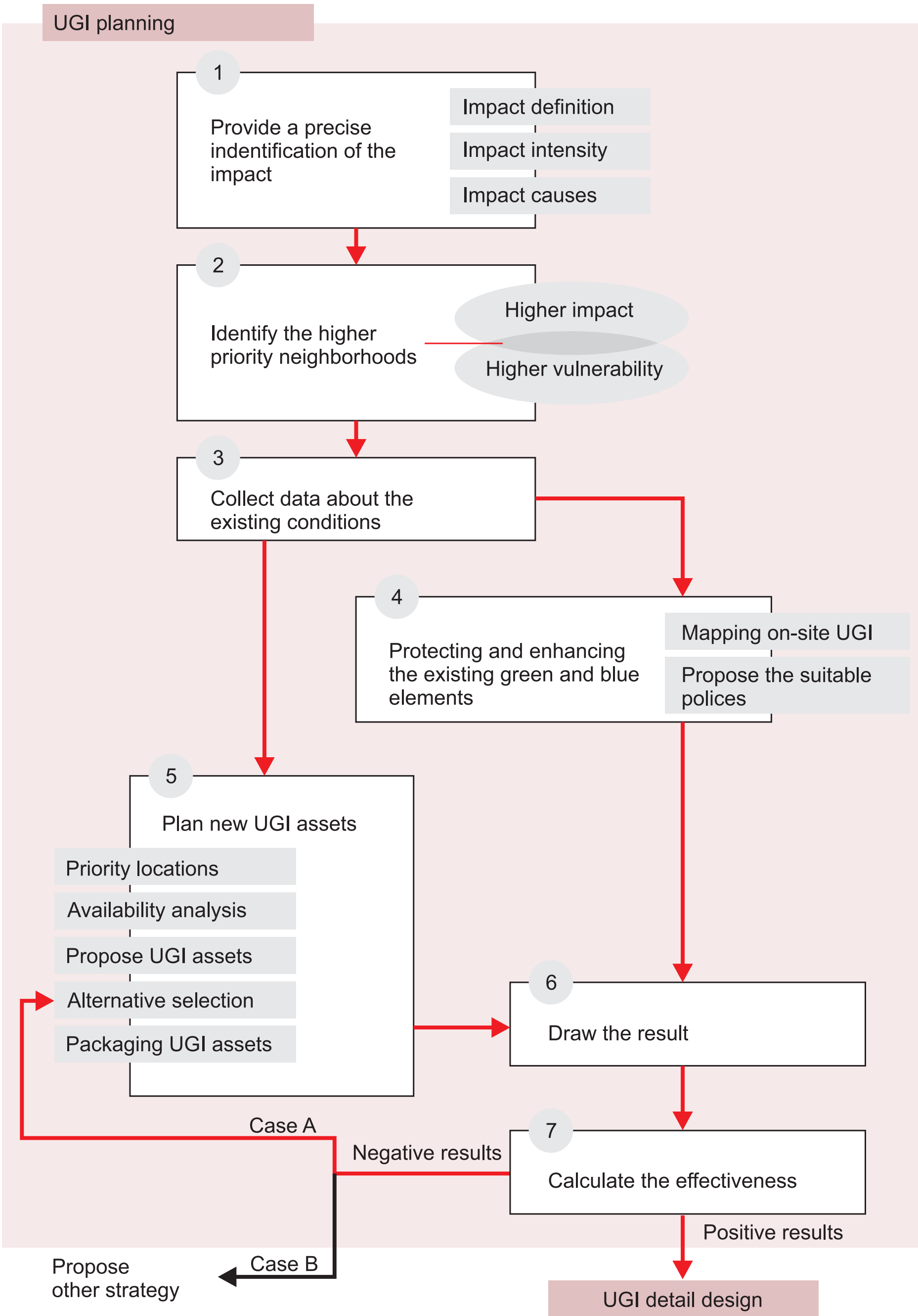

Fig. 2. Planning steps of urban green infrastructure in existing cities
Source: own preparation.

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Depending on the results of the effectiveness calculation, some main paths will be adopted across the planning process. If the results are positive, UGI strategy will be transferred to the next stage of "Detail design". If the results are negative and the effectiveness of UGI in coping with the targeted impact was previously proved (case A), UGI planning should be returned to step 5 as there is something to adjust in the process of adding new UGI assets such as the criteria of the alternative selection. If the results are negative and the effectiveness of UGI was not previously proven (case B), that means that the UGI strategy is not effective in countering this type of climate change impact and another strategy of CCSA should be proposed. This occurs rarely as proposing the strategy of CCSA, from the outset, should be based on its scientific proven success in coping with this type of climate change.

Understanding the extracted steps' definition and following their optimal sequence, can ensure having the best results of employing UGI in the field of CCSA. That can also avoid the risks of following non-reliable methods which can bear both of right and wrong choices. The extracted set of UGI planning steps provides a planning path that will acquire its unique identity from the first step of identifying the climate change local impact. So, these steps reflect a general rule that may vary in its details in different cases.

CONCLUSIONS

Finding a smart way of climate change adaptation gains greater importance, as the impacts of climate change become more severe and the opportunities to cope with them become more limited. Employing Urban Green Infrastructure offers a certain strategy to achieve such type of adaptation. Accordingly, the research imposed the question of what is the most acceptable definition and sequence of UGI planning steps in existing cities for Climate Change Smart Adaptation (CCSA). The research aimed to extract the optimal set of UGI planning steps from some real practices that already proved their efficiency. By exploring and comparing four case studies, it was found that UGI planning usually occurs within similar processes but under different definitions and arrangements. By analyzing these processes and clarifying the intersection between them, the optimal definition and sequence of planning UGI in existing cities were extracted and outlined in a set of "seven steps". Following such steps can ensure success and reduce the possibility of losing spaces or funds. At the same time, commitment with these steps can also offer flexibility to deal with the city's local conditions such as the type of climate change impact or the site opportunities to have UGI. These steps are linked to each other in a continuous chain as the result of each step forms a basic input for the following step. Identifying impact and vulnerability to define risk, for example, are essential steps to define where to begin. So, they form the starting point for UGI strategy at any specific scale. Also, the trade-off between potential UGI assets according to some environmental, social, and economic criteria assists in performing a deep feasibility study for each potential site or UGI assets. Taken together, these steps can form a coherent chain of activities to obtain a vital UGI strategy as they offer a pre-tested framework for UGI successful planning in existing cities. This framework can be applied to any city at it has an adequate amount of flexibility to take the city conditions into its account.

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