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Scoping for the Operation of Agile Urban Adaptation for Secondary Cities of the Global South: Possibilities in Pune, India

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Received: 8 November 2017; Accepted: 29 November 2017; Published: 2 December 2017

Abstract: Urban areas, especially in developing countries, are adapting to deficits in infrastructure and basic services (Type I adaptation) and to adaptation gaps in response to current and future climatic, societal and economic change (Type II adaptation). The responses to these adaptations needs can be integrated and implemented using an "agile urban adaptation process", i.e., an adaptive planning process quickly adapting to change in a flexible manner in short planning horizons, where the requirements and responses evolve through evolutionary development, early delivery, continuous improvement and collaboration between self-organizing and cross-functional teams. This paper focuses on how to move from the current conceptual stage to developing practical knowledge for the operation of agile urban adaptation. Scoping methodology comprises (i) understanding and structuring the adaptation context; (ii) exploring the four agile elements—balancing type I & II adaptation needs, flexibility, range of scenarios and involvement of stakeholders—in the adaptation context; (iii) a detailed SWOT analysis (strength, weakness, opportunities and threat) of adaptation responses; (iv) mapping relationships and synergies between the adaptation responses; and (v) preparing agility score cards for adaptation responses. The scoping exercise revealed that the agile adaptation process can move from concept to operation in Pune, India where the city is improving the basic services and adapting to climate change. For example: conventional adaptation responses such as city greening and check-dams across the rivers have agile characteristics; these responses are synergetic with other adaptation responses; and, there is a possibility to compare conventional adaptation responses based on agile characteristics. This scoping exercise also reveals that urban agile adaptation is not about implementing novel adaptation responses but understanding, planning and implementing conventional adaptation responses using an agile perspective. Urban agile adaptation is also about mainstreaming agile ideas using traditional adaptation responses. Hence, it is possible to apply agile the urban adaptation process using conventional adaptation responses in urban areas which address adaptation deficits related to infrastructure development as well as climate and socio-economic adaptation.

Keywords: agile adaptation; cities; climate adaptation; implementation; flooding; urban areas

1. Introduction

Urban areas are adapting to overcome the difficulties and make use of opportunities arising from climate change and other changes, which are both uncertain and complex [1]. Urban areas, especially in developing countries—the secondary cities of global south (SCGS)—are adapting to deficits in

infrastructure and basic services, i.e., Type I adaptation; and, to future adaptation needs that are due to climate change, social change and economic change, i.e., Type II adaptation [2]. The type I and type II adaptation responses are not implemented in consideration with each other leading to unnecessary expenditure, inconvenience and waste of opportunities and time [3–5]. However, there are difficulties in integrating Type I and Type II adaptation responses. Type I responses are characterised by urgency as they address the current absence or shortage of urban services, whereas Type II adaptation responses are characterised by uncertainty as they address long term changes [5]. Integration of adaptation responses is gaining prominence after the Paris 2015 accord as governments at various levels all over the world have started planning and implementing adaptation responses [6]. Also, understanding and integrating adaptation responses are important for achieving the sustainable development goals (SDG) [7], as one adaptation response can contribute towards achieving more than one goal [8]. For example, an urban wetland can contribute towards: sustainable cites (Goal 11), as it enhances liveability; climate action (Goal 13), as a buffer in the event of floods; life below water (Goal 14); and life on land (Goal 15). Also integrating responses is relevant in the context of "sponge cities", where various strategies and actions are expected to deal with excess and shortage of water [9,10]. The planning and implementation practises which are prevalent in other cities such as Copenhagen, Rotterdam and Singapore; and approaches advocated by international agencies such as United Nations Development Programme (UNDP), Sustainable Development Solutions Network (SDSN) can be used for (i) guiding the emerging approaches; (ii) overcoming the challenges; and, (iii) making use of the opportunities in the context of sponge cities.

Cities can learn from their experience or from the experience of other cities to address their adaptation deficits and adaptation gaps. For example, cities can learn from the August 2017 Houston floods on what went wrong in terms of urban planning, managing flood risks and why the city was so under prepared [11]. Leapfrogging is the ability of cities to rapidly transition to sustainable development by learning from the mistakes of other cities and adopting more efficient and ecologically friendly practices [8,12–14]. For example, developing wetlands for flood risk management is leapfrogging, as wet lands contribute to ecological improvement and also can lead to indirect economic benefits, unlike a dike or sluice gate which can be economically beneficial but affects ecology. The use of sustainable adaptation responses, such as using wetlands as part of management of urban fabric in the cities of developing countries, is a recent phenomenon, which was introduced upon realising that the conventional responses do not always lead to sustainable development and help in achieving multiple objectives [15]. Hence, leapfrogging potential is a very important criteria for assessing adaptation responses in a SCGS, especially in the context of sponge cities. Although leapfrogging can enable learning of planning and implementation practices from developed country context, it can be effective only if the there is a comprehensive understanding of the local adaptation situation and adaptation responses.

Understanding the local setting to provide appropriate context for action and structuring the local adaptation problems are essential for integrating adaptation responses (e.g., localising the SDG [8], structuring adaptation context and responses [4,16]). There are concepts such as transformative adaptation [17,18] and clumsy solutions [12], and processes based on flexibility such as adaptation pathways [19] and dynamic adaptive policy pathways [20] that enable sequencing and integration of various adaptation responses. However implementation challenges persist, such as proactive analysis of implementation issues during planning stage, contested values, changing goals and objectives and integration of adaptation responses across spatial scales and temporal scales [16,21]. Recent approaches such as agile urban adaptation [13] and flexible adaptation planning processes [22] address some of these challenges in implementing adaptation responses.

Agile adaptation is an adaptive planning process that adapts to change in a flexible manner over short planning horizons, where the requirements and responses evolve through evolutionary development and involves early delivery, continuous improvement and collaboration between self-organizing and cross-functional teams [13,23,24]. Agile adaptation is also seen as an implementation

and operational tactic to achieve a set of desired outcomes by quickly adapting to changing needs and making use of opportunities by the stakeholders involved in adaptation planning and implementation [25]. Although application of agility has empirical evidence in software and automobile industry [23,26–28], it is yet to be implemented for urban planning and adaptation management. Pathirana et al. [13] have developed an agile urban adaptation planning process and theoretically demonstrated its application in a complex setting in Can Tho city, Vietnam. The agile urban adaptation process has been presented as a tactic to sustain continuous adaptation and continuous learning in short cycles, using conventional adaptation responses such as dike construction, urban drainage and household measures [13]. The four agile elements identified by Pathirana et al. [13] as essential for the application of agile urban adaptation are: (i) harmonizing type I & II adaptation needs; (ii) flexibility of adaptation responses; (iii) addressing plausible scenarios; and (iv) continuous involvement of stakeholders in the decision making process. However, the way forward to use the agile adaptation using adaptation responses that are already planned following a traditional approach is missing.

Pathirana et al. [13] has demonstrated that it is possible to apply agile adaptation in urban areas. However, the application is still at a programme-tactical level to identify the local adaptation possibilities and pre-requisites to implement an agile adaptation strategy. The pre-requisites for becoming agile at city and household levels is the identification of agile attributes of adaptation responses. At present, there is a lack of knowledge on agility attributes at a project level. Lack of practical knowledge to use agile urban adaptation is a significant gap for application. Hence this paper focuses on developing practical knowledge for using agile urban adaptation. A simple methodology based on tools and concepts that are frequently used by city managers, planners and engineers will be helpful in understanding the concept of agility, select agile adaptation responses and implement them. Hence a simple methodology, straightforward and comprehensive to city engineers, for using agile urban adaptation has been developed. The methodology comprises the following steps: understanding the local adaptation setting inspired by SDGs [8]; SWOT analysis (strength, weakness, opportunities and threat) that is widely used in business, industry and strategic planning [29]; and analysis based on the four agile elements [13]. Also this methodology has been tested in Pune, India—a SCGS—which is improving civic amenities and adapting to climate change.

2. Methodology

Using the agile adaptation process requires the understanding of the adaptation responses, stakeholders, motivations and capacities at different levels from global to household [4,13]. Globally, the sustainable development goals—comprising climate action as a goal—have gained prominence, where the emphasis is on implementing adaptation responses [6,7]. This necessitates understanding the (i) attributes of adaptation response at the local point of application or implementation; (ii) interaction among the responses; (iii) strength and weakness of the responses; and, (iv) opportunities and threats to the adaptation responses in the local point of implementation. The steps in the methodology for using agile urban adaptation process are: (i) understanding the local adaptation needs and adaptation responses (i.e., local setting) inspired by SDGs [8]; (ii) SWOT analysis of adaptation responses; (iii) mapping of synergies and relationship between responses [30,31]; and (iv) preparing agility score cards for adaptation responses [13]. The agility score card comprises the four agile elements, as well as criteria on the leapfrogging potential of the adaptation responses. SWOT analysis is a simple, open and transparent process which can be easily done by the stakeholders in the city who are involved in the planning and implementation of the adaptation responses. Also, developing the qualitative agility score card for adaptation measures is simple, transparent and based on identifiable characteristics such as flexibility, Type II adaptation needs, stakeholder involvement and plausible scenarios. The methodology is presented in Figure 1. Although the operational process appears linear, every individual step involves a number of iterations.

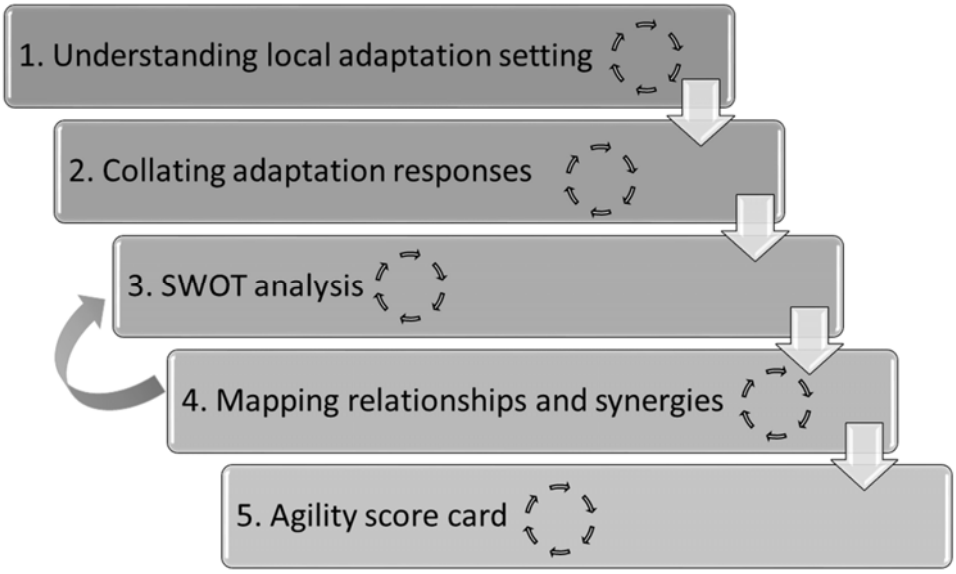

Figure 1. Scoping for using an agile urban adaptation process using a five step operational process.

Understanding the local adaptation setting (Step 1): This process is carried out by reviewing (i) the city's existing urban planning and adaptation planning documents; (ii) relevant literature which assesses the climate, social, economic and political developments; (iii) compliance and guidance documents on infrastructure and basic service levels of cities, such as service level bench mark (SLB) of Indian cities [32]; (iv) partnerships and cooperation agreements on development and adaptation with national and international agencies; and (v) consultation and interviews with stakeholders. This step enables a comprehensive understanding of adaptation and development gaps in the city and helps in structuring the local adaptation problem [4] and localising the SDGs [8]. Such an understanding will also help in identifying major drivers of adaptation, the relationship among adaptation drivers and prioritise the adaptation or development needs.

Collating adaptation responses (Step 2): The various adaptation and development responses planned and implemented in the city are collated using the same set of documents mentioned in Step 1. One useful and ready to access source to start with the collation of basic information about adaptation responses is the annual city budget documents, i.e., the fiscal planning documents and the annual audited statements from the previous years of the city or municipality. Analysing the budget allocated in the current budget plan, the past budget plans and the past annual expenditure will also reveal the trends in expenditure incurred and the preference of adaptation responses. Also, the detailed characteristics of responses—such as need for the responses, nature of responses, purpose of the responses, scale of responses, stakeholders, functional life time of the responses—are collected in order to understand the responses.

SWOT analysis (Step 3): The strengths, weakness, opportunity and threat analysis of the various adaptation responses (collated in Step 2) are carried out. SWOT analysis should be carried out only after understanding and structuring the local adaptation setting (Step 1) to enable a comprehensive analysis. Also, it is strongly recommended to carry out the SWOT analysis together with all the stakeholders as the opinion from a diverse group would reveal the hidden strengths, weakness, opportunities and threats making the result more comprehensive and representative. The diverse group of stakeholders involved in adaptation planning and implementation are urban planners, city engineers, provincial governments, people representatives, service providers such as civic amenity contractors and policy makers. The SWOT analysis will also bring out the multiple benefits of the adaptation response, such as the wetland example which has disaster reduction, liveability enhancement, land improvement and water ecosystems benefits.

Mapping relationships and Synergies between adaptation responses (Step 4): Understanding the adaptation setting helps in identifying the relationships and synergies among the adaptation responses. For example, in case of Can Tho City, Vietnam, it is reported that linking of planned dike enhancement responses with the autonomous household level responses increases the functional life span of dikes [33]. However, linking these responses has an adverse impact on the water quality due to mixing of flood water with sewage [34]. Thus, mapping of relationships between the adaptation responses reveal the hidden threat and opportunities, which further strengthens the SWOT analysis. The 30-year infrastructure development strategy document developed by the Victorian Government, Australia provides a good guidance on mapping the relationships between the adaptation responses [30,35]. Further mapping relationships among the responses helps in identify the opportunities for mainstreaming to implement adaptation responses together with other infrastructure components [36]. Identifying the synergies can be across spatial and temporal scales involving multiple community and sectors [37].

Agility score card for adaptation responses (Step 5): Based on the four agile elements a qualitative score card can be prepared for all the adaptation responses considered so that they can be compared with each other and to understand the overall agility of the city's responses. The score card comprises five criteria. The four criteria representing the four agile elements are: (i) scope for addressing Type I and II needs; (ii) flexibility of adaptation response; (iii) validity across a range of scenarios; and (iv) involvement of stakeholders in all the stages of planning, implementation, operation and monitoring of the adaptation response. In addition to the four agile elements, 'leapfrogging potential' has been included as a fifth criteria due to its crucial importance for developing cities.

This methodology is tested in Pune City in India. The main outcome of the application is how to identify the presence of agile elements and switch to an agile urban adaptation practice in a conventional adaptation context comprising conventional adaptation responses. The focus in this paper is limited to adaptation responses which enhance urban flood resilience.

3. Case Study Application

Pune (Figure 2), the ninth largest Indian city located close to Mumbai, is an important educational, industrial and military hub [38]. Spread over 276 sq.km, the total population of Pune city was about 3.1 million in 2011 [38]. Pune is a hilly city and is located in the confluence of two rivers Mula and Mutha [39]. According to the Government of India's service level bench marking (SLB), Pune ranks high among the Indian cities in terms of basic city service levels such as provision of water and sanitation, electrification, etc., [32]. Disease outbreak, lack of affordable housing, earthquake, water insecurity and pluvial flooding are some of the major threats to Pune [40]. Although Pune Municipal Corporation is responsible for running the city a number of agencies at state, national and international level also contribute to the development of Pune either because of their mandate or through special projects (Table 1).

Understanding the local adaptation context in Pune: The current developmental needs (Type I) of Pune are evident from the gaps in the service level bench marks (Table 2). There is a gap with respect to sewage treatment, improvements to road side drains, ecological improvements and water security. The adaptation needs (Type II) of Pune city is likely to be affected by changing climate, population and economy. The changing climate, represented by four equally likely scenarios [41], is likely to influence precipitation which can become more erratic with heavier extreme rain fall events and longer periods of dry spells [42]. This has a direct impact on the water security and pluvial flooding related problems in Pune [43]. Furthermore, the population in Pune at Year 2027 is likely to be at 5.7 million in a low growth rate scenario and 6.2 million in a high growth rate scenario [44]. There is uncertainty in number of people migrating to Pune and uncertainty in the changes to land use patterns [44]. Hence, the impact of flooding such as number of people displaced or the economic damages due to flooding is influenced jointly by climate change, demographic change and land use change in Pune. This leads

to a multiple adaptation needs context with Type II adaptation. However, the magnitude of the impact and responses are likely to vary depending on the scenario.

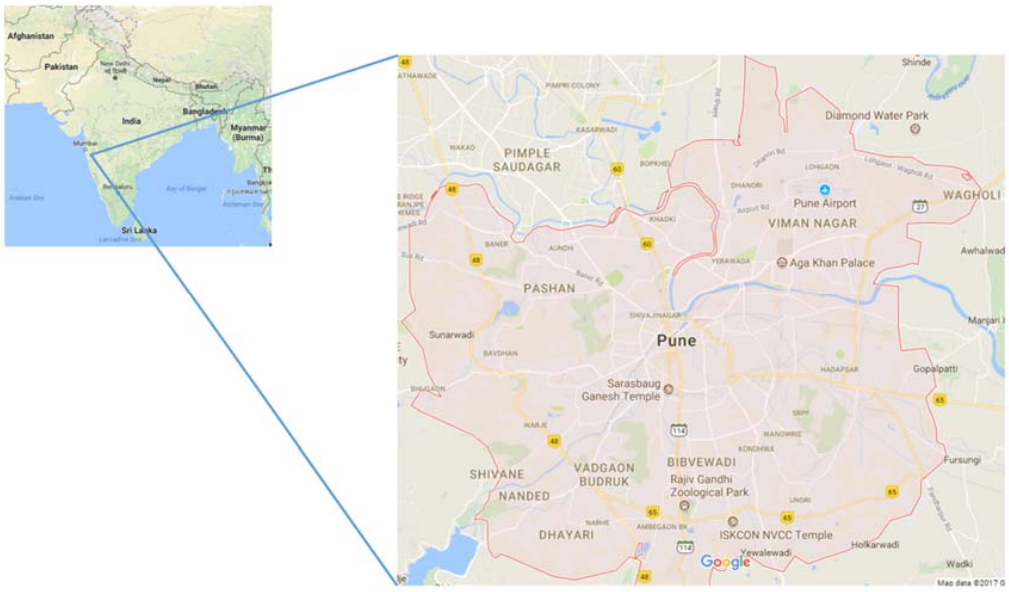

Figure 2. Map showing location of Pune in India (Source: Google maps www.goo.gl/ED9SHA).

Table 1. List of various agencies and Projects involved in planning and implementation of adaptation responses in Pune.

AMRUT	**Atal Mission for Rejuvenation and Urban Transformation**
Cantt	Cantonment
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CWPRS	Central Water and Power Research Station
GoI	Government of India
GoM	Government of Maharashtra
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
MIDC	Maharashtra Industrial Development Corporation
MoUD	Ministry of Urban Development
MSRDC	Maharashtra State Road Development Corporation
NGO	Non-Governmental Organisation
NHAI	National Highways Authority of India
NRCD	National River Conservation Directorate
PCMC	Pimpri Chinchwad Municipal Corporation
PMC	Pune Municipal Corporation
PMRDA	Pune Metropolitan Region Development Authority
RFD	River Front Development
ZP	Zilla Parishad (District Council)

Table 2. Gaps in infrastructure and basic service levels in Pune.

Service Level Parameters for Indian Cities	**Desired Service Level Benchmark**	**Current Service Levels of Pune ***	**Reference**
	Water Supply		
Coverage of Water Supply connections	100%	90%	ESR [45]
Per Capita Supply of Water	135 L/pers/day	90–120	Smart City Plan [46]
Extent of Non-Revenue Water	15%	30%	Smart City Plan [46]
Extent of Metering	100%	30%	ESR [45]
Continuity of Water supplied	24 h/day	5 h/day	ESR [45]
Efficiency in redressal of customer complaints	80%	100%	ESR [45]

Table 2. *Cont.*

Service Level Parameters for Indian Cities	Desired Service Level Benchmark	Current Service Levels of Pune *	Reference
Water Supply			
Quality of Water Supplied	100%	100%	ESR [45]
Cost Recovery	100%	71%	City development plan [47]
Efficiency in Collection of Water Charges	90%	91%	ESR [45]
Solid Waste Management			
Household Level Coverage	100%	60%	ESR [45]
Efficiency in Collection of Solid Waste	100%	100%	ESR [45]
Extent of Segregation of Solid Waste	100%	44%	ESR [45]
Extent of Solid Waste recovered	80%	80%	ESR [45]
Extent of Scientifically sound Disposal	100%	50%	ESR [45]
Extent of Cost Recovery	100%	80%	ESR [45]
Efficiency in Collection of SWM Charges	90%	80%	ESR [45]
Efficiency in Redressal of Customer Complaints	80%	91%	ESR [45]
Sewerage			
Coverage of Toilets	100%	98%	ESR [45]
Coverage of Sewerage Network	100%	99%	ESR [45]
Collection efficiency of Sewerage Network	100%	80%	ESR [45]
Adequacy of Sewage Treatment Capacity	100%	76%	ESR [45]
Quality of Sewage Treatment	100%	100%	ESR [45]
Extent of Reuse and Recycling of Sewage	20%	8%	ESR [45]
Extent of cost recovery in waste water management	100%	90%	ESR [45]
Efficiency in redressal of customer complaints	80%	80%	ESR [45]
Efficiency in Collection of Sewage Water Charges	90%	80%	ESR [45]
Storm Water Drainage			
Coverage	100%	55%	City development plan [47]
Incidence of water logging	0 numbers	52 Nos.	City development plan [47]

* The current service level bench marks are obtained from the reports that are prepared by Pune Municipal Corporation or by consultants commissioned by Pune Municipal Corporation. Hence there is a chance of over reporting, which has to be verified.

Collating adaptation responses: Although most of the adaptation responses in Pune focus on Type I adaptation needs (i.e., adaptation deficit), they can be expanded or modified to satisfy the Type II needs, which is adaptation gap. Most of the Type I adaptation needs in Pune such as gaps in water supply and drainage are overcome through basic infrastructure service initiatives, which is evident from Pune's budgetary plans [48]. The Smart cities missions, Atal Mission for Renewal and Urban Transformation (AMRUT), National River Conservation Directorate (NRCD)—Japan International Cooperation Agency (JICA) initiative, Swach Bharat Mission/Clean India Mission, Heritage City Development and Augmentation Yojana/plan (HRIDAY) are some of the programmes through which Type I and II gaps are being dealt with in Pune [38]. The adaptation responses relevant to water security and pluvial flooding (Figure 3) under the aforementioned programmes are: (i) additional water intake from Mulshi Dam [48]; (ii) vision 24 × 7 water supply [46]; (iii) rain water harvesting [48]; (iv) storm water drains [48]; (v) increase in sewage treatment capacity [49]; (vi) expansion of sewer trunk mains [49]; (vii) strengthening river embankments [49]; (viii) plantations, gardens and open spaces [49]; and (ix) check dams across rivers [49]. The collated adaptation responses fall into three board categories: (i) ensuring water supply and quality; (ii) preventing flooding and river; and (iii) river front development, which can cater to both Type I and II adaptation needs. The details of adaptation measures such as nature of adaptation and location of the measures are shown in Figure 3. Various stakeholders are involved in every adaptation response (Figure 4). Understanding the attributes of the adaptation responses based on the programme, ownership, funding, engineering, procurement and construction (EPC), operation and maintenance (O&M) enables the mapping of responsibilities of stakeholders (Figure 5). This can facilitate the understanding on the extent of stakeholder involvement. Being aware of the spatial and temporal distribution of the responses, programmes, funding source and stakeholders helps in establishing the relationships between the responses.

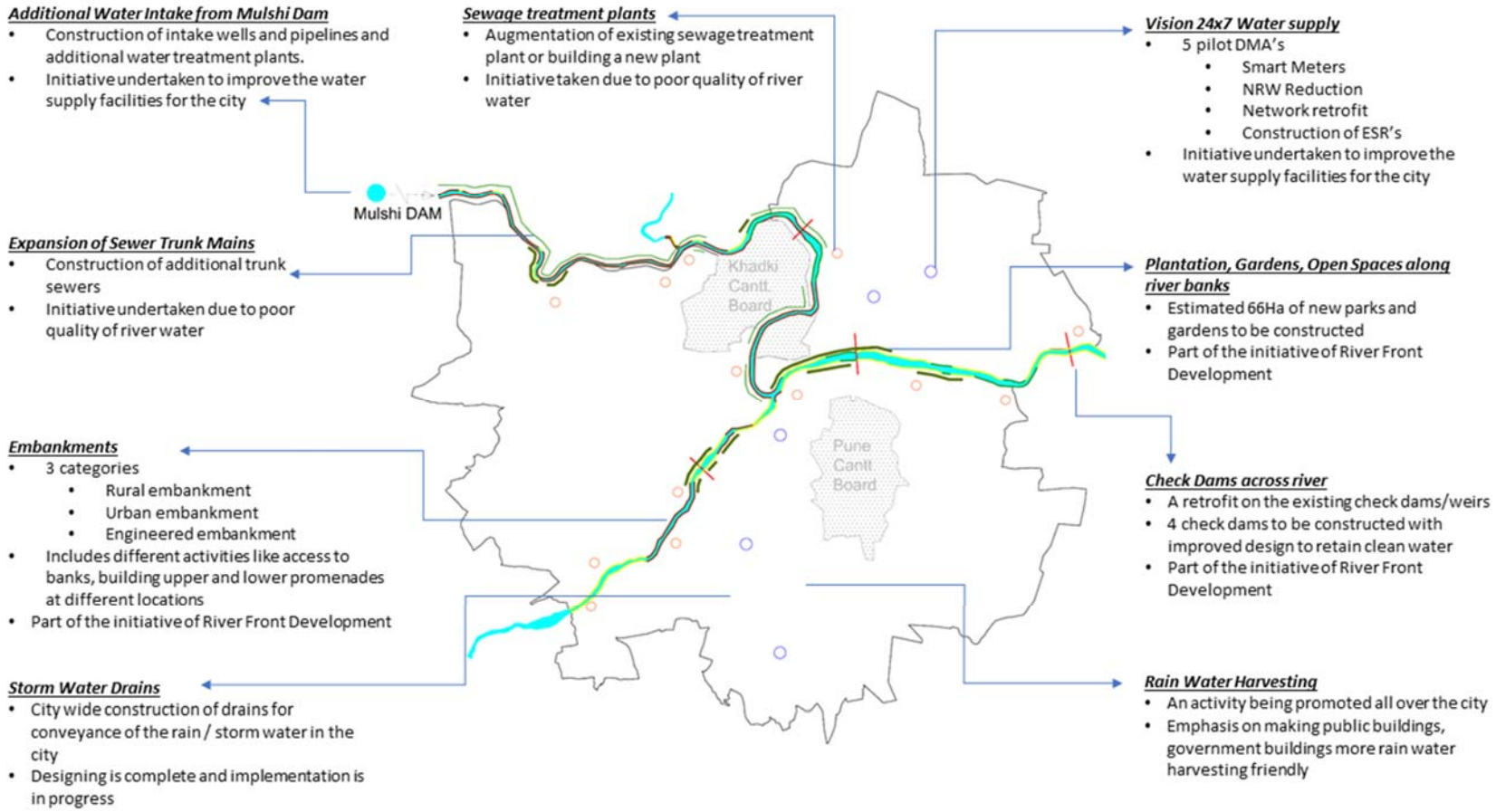

Figure 3. Adaptation responses for Pune, collated from existing planning documents.

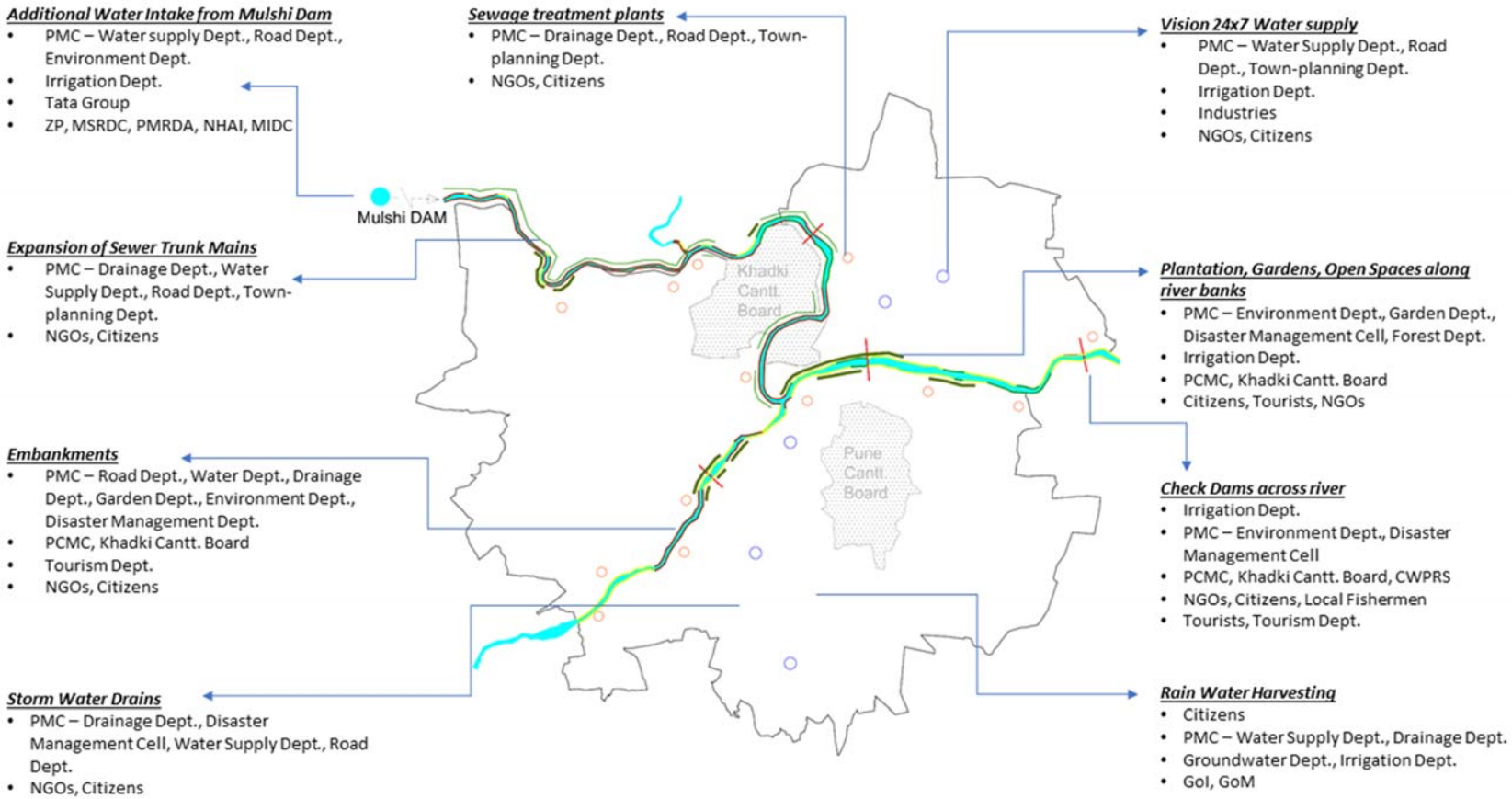

Figure 4. Stakeholders involved in adaptation responses.

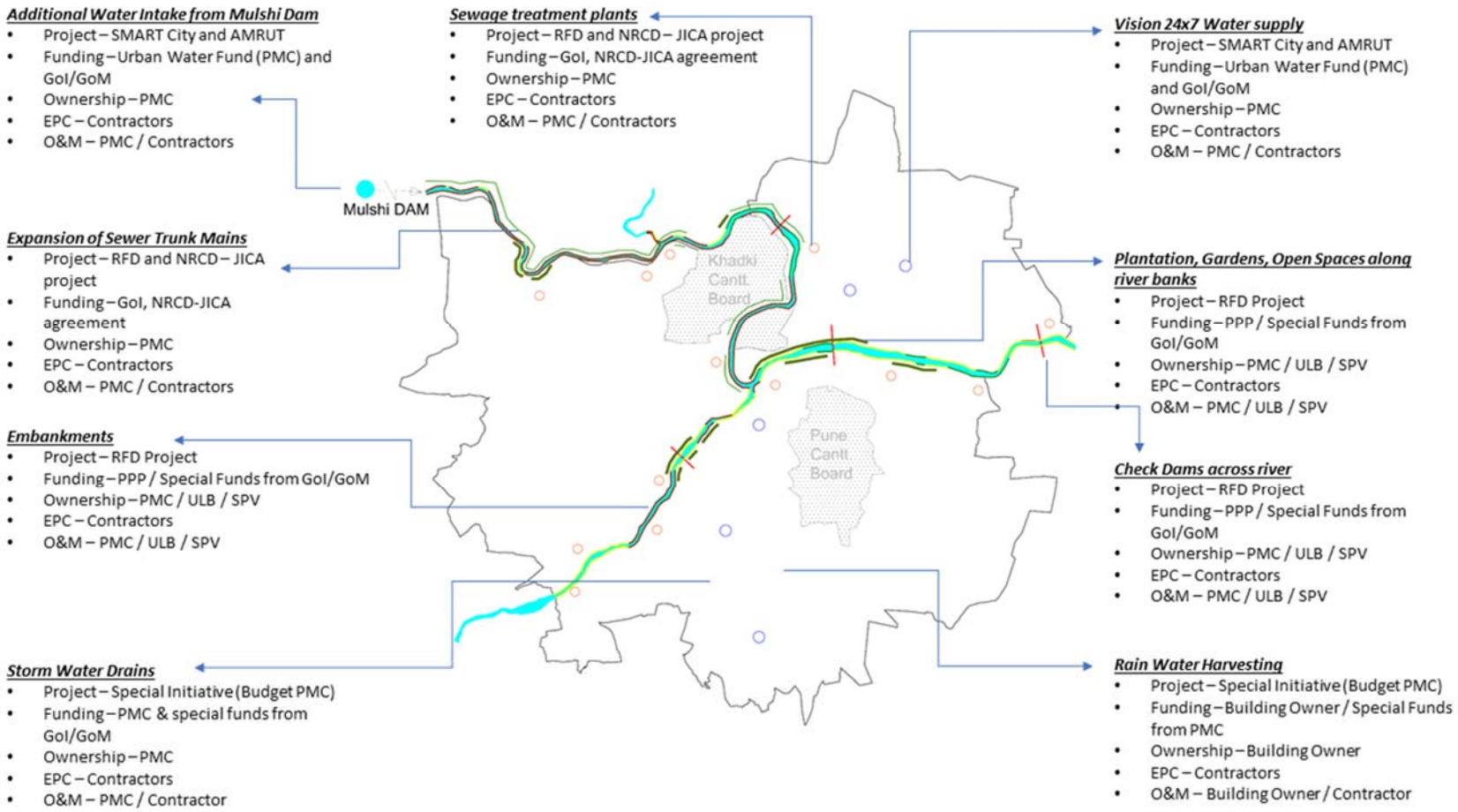

Figure 5. Funding and ownership details of adaptation responses.

Table 3. SWOT analsysis of Adaptation responses.

Additional Water Intake from Mulshi Dam		**Sewage Treatment Plants**		**24 × 7 Water Supply**	
Strength Assured water availability and water transport	*Weakness* Dependency on single source Too many competing stakeholders	*Strength* Improved river water quality	*Weakness* Land acquisition and public acceptance for facility in the vicinity	*Strength* Improved service levels	*Weakness* Lack of coordination between Planning and water department
Opportunity Possibilities to develop a regional water plan and secondary water sources Possibilities for institutional arrangements between stakeholders	*Threat* Failure will have cascading effect Land acquisition and implementation hurdles might lead to delay and cost escalations	*Opportunity* Possibilities to design and implement nature based treatment system using gardens, wet lands and open space	*Threat* High probability for plant to reach peak capacity before the end of design period	*Opportunity* Possibilities for institutional arrangements between stakeholders Possibilities to postpone water intake works	*Threat* Likely changes in population density and land use patterns
Expansion of Trunk Sewer		Check Dams in River		Gardens and Open spaces along the river	
Strength Better public health and river water quality Guaranteed funds	*Weakness* Construction hurdles in densely populated areas	*Strength* Increased water availability, flood control and regulated silting	*Weakness* Land acquisition O&M difficulties	*Strength* Improved biodiversity, embankment strength and flood protection	*Weakness* Land acquisition O&M difficulties
Opportunity Mainstreaming with roads, electric cables, etc., Possibilities for stakeholder institutional arrangements	*Threat* Dumping of solid waste might lead to O&M difficulties High path dependency leading to future complications.	*Opportunity* Construction compatibility with embankments and recreation facilities	*Threat* Hindrance to navigation Lack of warning system, preparedness and operational protocol during cloudburst.	*Opportunity* Mainstreaming with transportation, recreation, urban farming and open space facilities	*Threat* Increased public access to riparian areas is a threat to ecosystems.
Embankments		Strom Water Drains		Rainwater harvesting	
Strength Better access to river side leading to increase in public and tourist activity	*Weakness* Relocating existing infrastructure such as Dobhi ghats	*Strength* Reduced water logging, road accidents and health issues	*Weakness* Removal of encroachments and availability of funds	*Strength* Improved ground water levels	*Weakness* High dependency on proactive public participation
Opportunity Mainstreaming with roads, electric cables, gardens, etc., Possibilities for institutional arrangements between stakeholders	*Threat* Land acquisition issues leading to cost overruns and time delays	*Opportunity* Mainstreaming with roads, electric cables, gardens, etc., Possibilities for institutional arrangements between stakeholders	*Threat* Land acquisition issues leading to cost overruns and time delays	*Opportunity* Reduced dependence on city water supply Tax/water tariff incentives	*Threat* Lack of adequate maintenance and water quality issues.

SWOT analysis: The strengths, weakness, opportunities and threats of all the adaptation responses in Pune have been analysed (Table 3). From Table 3 it can be seen that the strength of the responses are specific to the objectives of the responses, whereas common weaknesses, opportunities and threats can be seen across the responses. For example, difficulty in land acquisition is a common weakness across responses such as check dams, storm water drains and open area development. Whereas difficulty in land acquisition is a threat to intake works and embankments, engagement with stakeholders is an opportunity across most of the responses. A weak or inadequate stakeholder engagement is a threat to intake well adaptation response. In addition to enhancing the understanding adaptation measures, the SWOT analysis also helps in understanding the implementation bottlenecks (Figure 6) as well the possible collaborations across the adaptation responses (Figure 7).

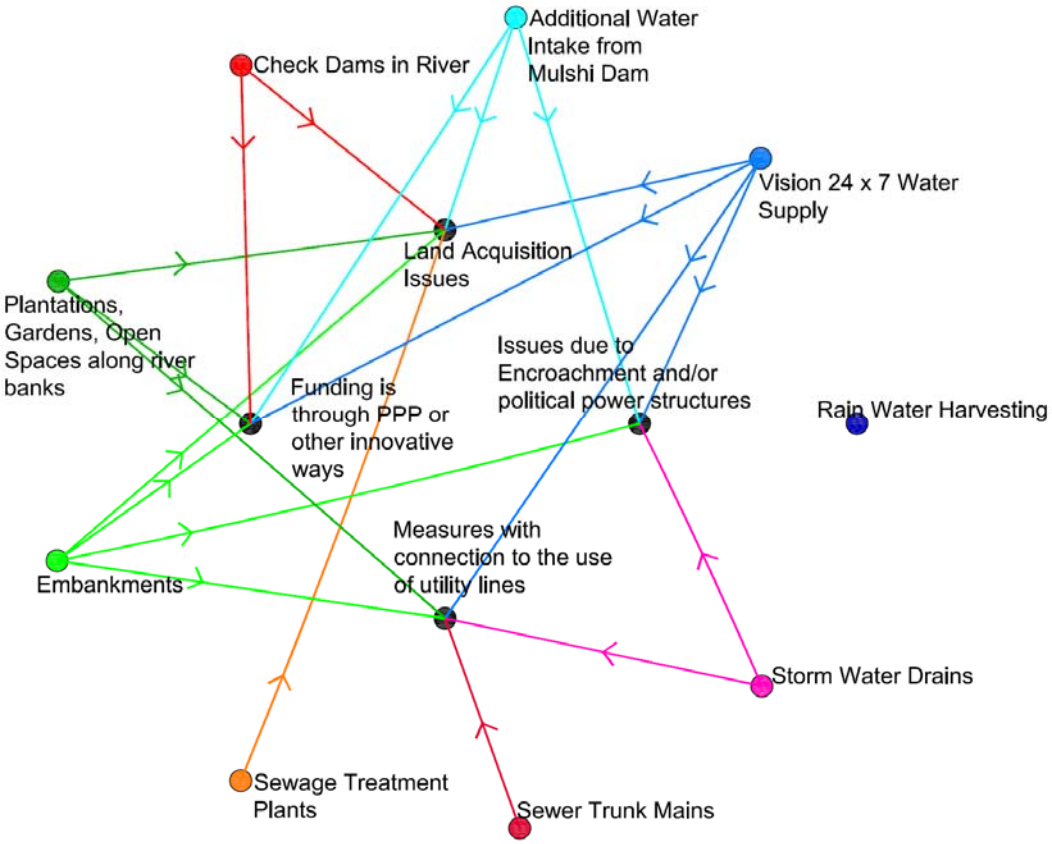

Figure 6. Common implementation bottlenecks in implementing adaptation responses. The arrows originate from the adaptation responses and terminate at the probable bottlenecks which are likely to hinder the response during planning or implementation.

From Figure 6 it can be seen that the common bottlenecks for implementation of the adaptation responses are land acquisition, funding mechanisms, clearing encroachments in project sites and interference with utility services (such as telecommunications, electrical distribution and traffic, as the water pipes and sewers share the same service corridor). However, becoming aware of the bottlenecks across the adaptation responses also gives an opportunity to understand and resolve them. The sewage treatment plants that are planned at multiple locations in Pune are likely to face objections from people living in the vicinity due to foul odour [50]. Also the open space plan and embankment project are likely to face objections from the community residing in the vicinity of river and involved in professional laundry services, as implementing these responses can lead to displacement and livelihood issues [50]. However, from Figure 7 it can be seen that there are possibilities to improve stakeholder participation,

improve coordination between utility departments, and adopt comprehensive flood management in Pune, which is based on the commonalities between the adaptation responses.

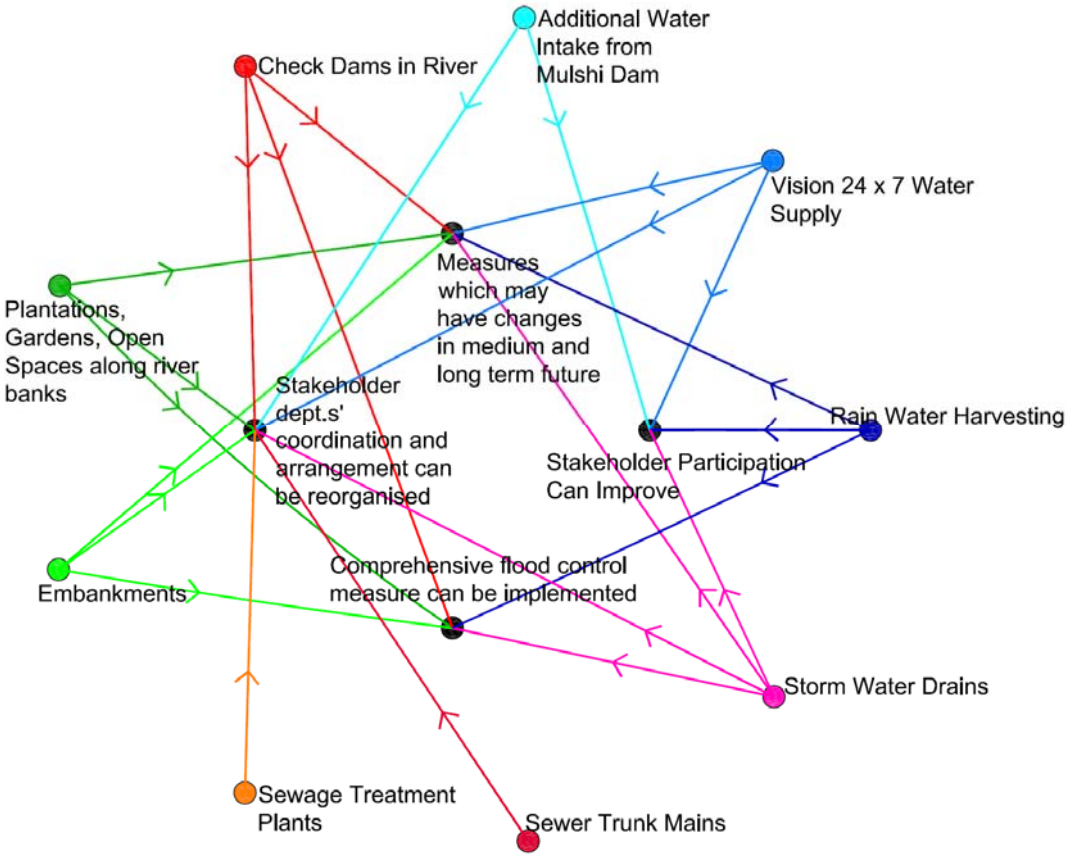

Figure 7. Possible collaboration between adaptation responses (The arrows represent the contribution of response to the common goal, i.e., the arrows originate from the adaptation responses and terminate at the favourable outcome(s) that the adaptation responses are likely to yield during planning or implementation).

Mapping relationships and Synergies between adaptation responses: Understanding the adaptation context and SWOT analysis of adaptation responses in Pune helped in identifying the relationships and synergies among the adaptation responses (Figure 8). For example, the intake works, 24 × 7 water supply and rainwater harvesting responses are related as they all cater to various water demands, storm water drains are related to the embankments and open space management plans as there is a spatial and functional overlap between these responses that can be modified if open areas are designed to detain storm water during intense rainfall. Similarly, the embankments can be related to the functionality of open areas in the city.

Understanding the relationships between adaptation responses (Figure 8) can lead to the identification of synergies between the adaptation responses (Figure 9). For example, supplementing water supply through rainwater harvesting has direct relevance to 24 × 7 water supply, which can lead to change in design of water supply mains and intake well design. This can lead to possible cost savings in terms of reduced water consumption from the mains and savings in energy to deliver water. Amalgamating storm water drains, sewer mains, river embankments and open space management plans can lead to change in design of the measures, coordinated implementation, operation and maintenance. There is good scope for realising the synergy in form of ecosystem benefits if the open space management plan can be coordinated with the sewerage treatment plants and embankments.

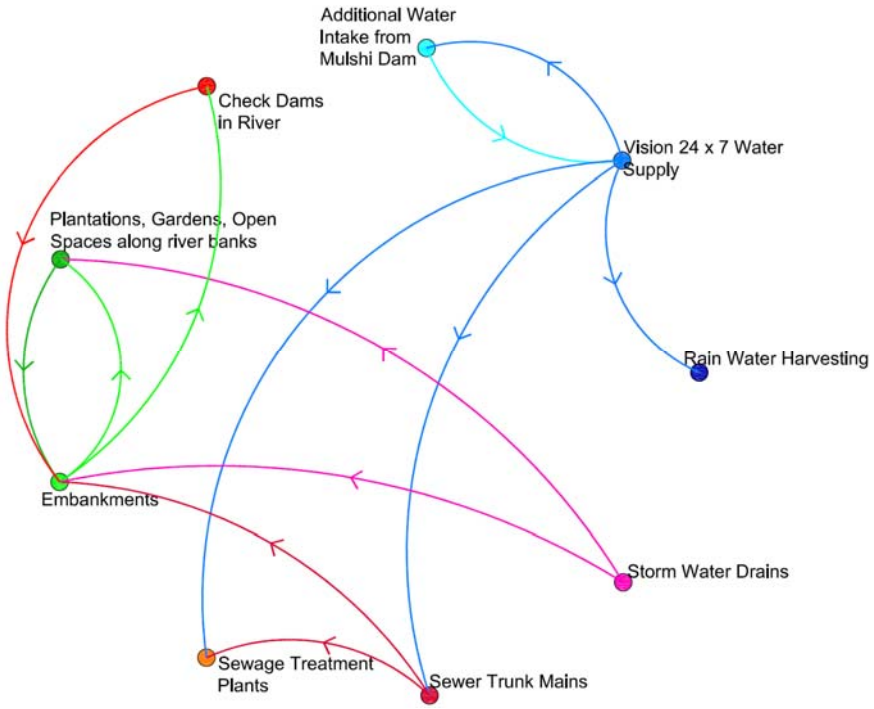

Figure 8. Mapping relationships between adaptation responses The arrows originating from an adaptation responses and terminating at other the adaptation response(s) is the representation of relationship between the responses, i.e., change in one response is most likely to lead change in the other response.

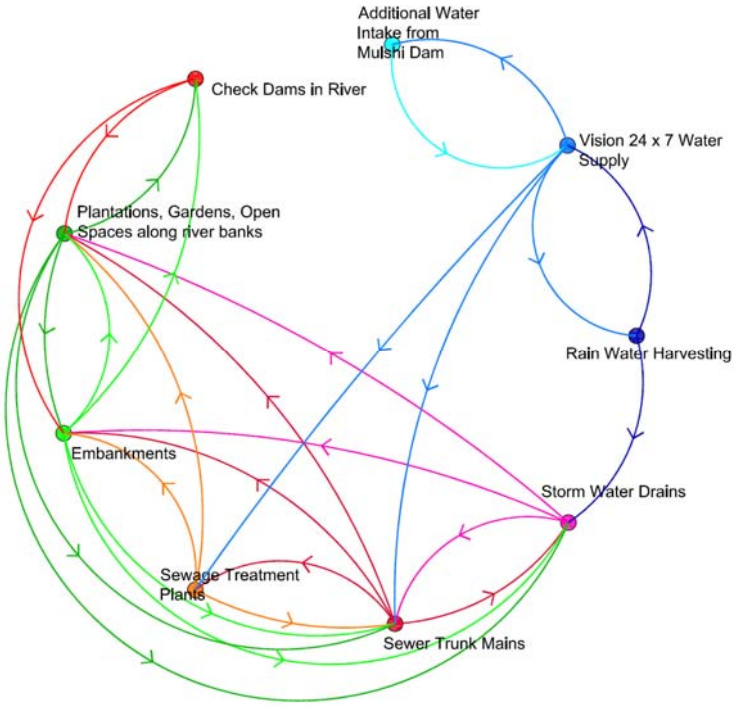

Figure 9. Synergies between adaptation responses. The arrows originating from an adaptation responses and terminating at other the adaptation response(s) is the representation of synergy between the responses, i.e., planning and implementing the responses together is likely to yield a greater benefit than planning and implementing in isolation.

Agility score card for adaptation responses: An agility score card based on four agile elements and leapfrogging potential was prepared for all the adaptation responses in Pune. The agility scores for all the adaptation measures in Pune were allocated based on the expert judgement of the authors. The expert judgement of the authors relied on: (i) the authors' own experience in planning and implementing adaptation responses; and (ii) interviews with various stakeholders in Pune who are involved in the planning and implementation of adaptation responses. Hence the agility scores are highly subjective. The range of qualitative agility scores is 0–5. Zero indicates that it is not possible to incorporate the agile element; one indicates the possibility to find or incorporate agile element is low; two indicate that the chances are medium; three indicate that the chances are good; four indicates that the chances are very good; and five indicates the best opportunity to incorporate the agile element in the adaptation response. The agility sore card for adaptation responses in Pune is presented in Figure 10.

The additional water intake from Mulshi dam has very limited flexibility as it an established practice to incorporate redundancy in the engineering design of pipelines and intake wells based on a future water demand [51]. However, structural flexibility is provided in certain aspects, like the design of bays for pumps which can be easily changed with change in demand. A score of one was assigned to flexibility of water intake works. This response is designed with an objective of satisfying water demand and will become redundant in the event of a bad water quality at the reservoir. A score of three was assigned to the performance of intake works in plausible scenarios. The design of intake facilities does not account for climate change and only considers population increase. A score of one was assigned to Type II adaptation needs consideration. It was evident from discussion with PMC officials that the planning and designing of intake works has been discussed and debated with various departments such as irrigations and dams, roads and with revenue departments due to water allocation, road cutting and land acquisition activities associated with this work [50]. The land owners along the pipe alignment were consulted, but consultations with end users in the city are missing. Hence, the stakeholder consultation component was assigned a score of three. There is no significant contribution to leapfrogging as this response is designed based on a conventional water supply– demand approach, except in terms of use of advanced technology in terms of providing energy efficient pumps and smart operation of pumps. Hence a leapfrogging score of one is given to this response.

Also, from Figure 10 it can be seen that responses such as gardens and open spaces have high agility scores of four across all agility elements. The response can be implemented in a flexible manner spatially and temporally. The open spaces can cater to a variety of plausible scenarios and can address the type II needs. There is also stakeholder involvement in terms of consultation, operation and in maintenance [43,46,50]. This measure helps in leapfrogging as it improves the environment and ecological aspects of the city.

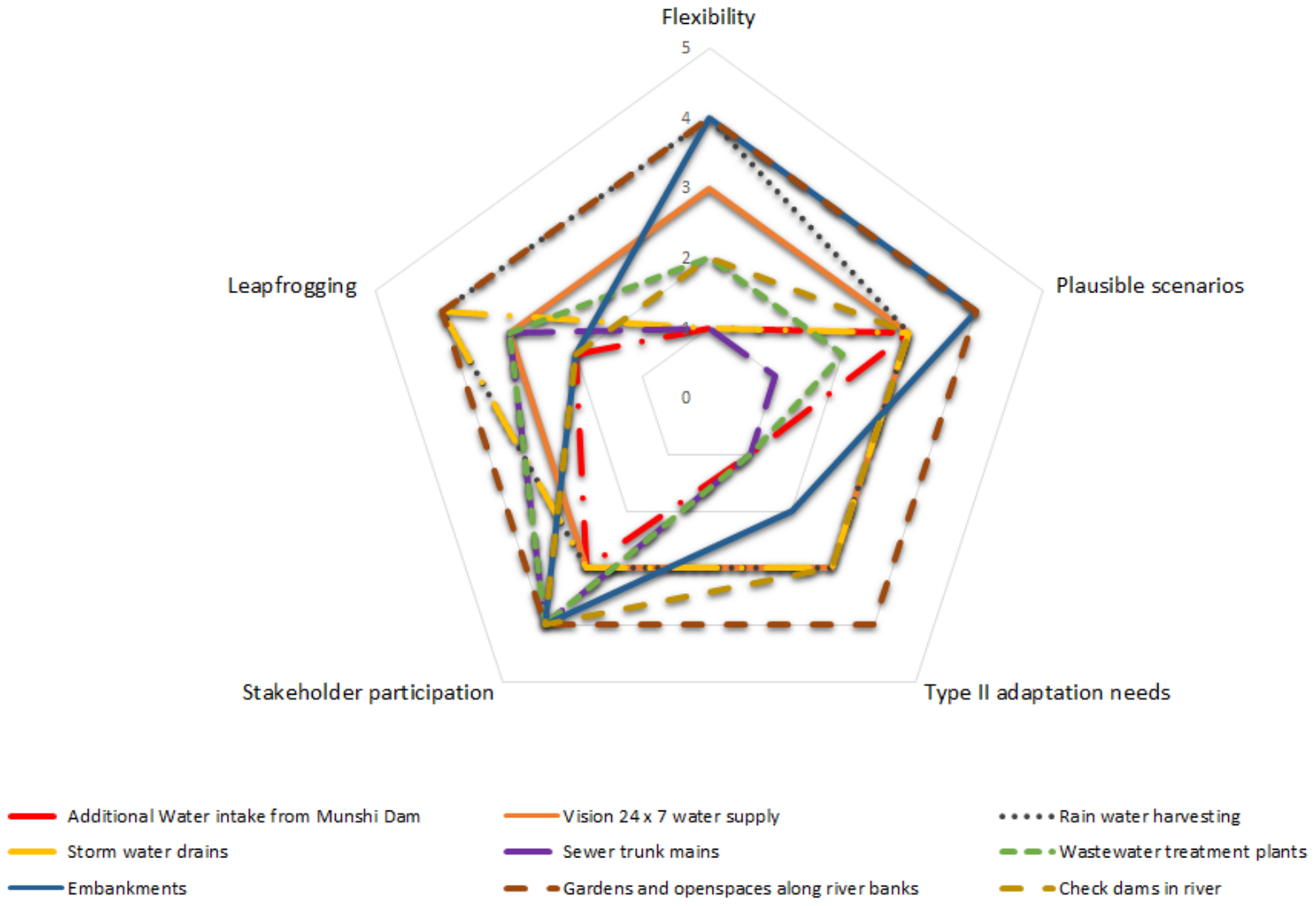

Figure 10. Agility score card for adaptation responses.

4. Discussions

Cities have already connected adaptation goals with development needs at a strategic level (e.g., Surat, Semarang [52]) but are striving hard to strike a balance between development (Type I) and adaptation (Type II) [53]. From the application of the agile urban adaptation process in Pune it is evident that Type I and Type II needs can be integrated at planning and implementation levels. SWOT analysis, mapping of relationships, synergies and the agility score card for responses reveal that agile urban adaptation can be implemented using conventional adaptation responses.

Conventional responses and unconventional process: The scoping exercise in Pune has revealed that conventional adaptation responses such as rain water harvesting, open area development and check dams have agile characteristics. Qualitative analysis of agile elements reveal that the nature of agile characteristics varies across adaptation responses. For example, the check dam has a high score with respect to stakeholder participation but a low score for flexibility. The embankments have high flexibility but very low leapfrogging potential. Overall, there is a high score for stakeholder involvement and there is an equal spread in the scores for other agile elements. This understanding can help in redesigning the responses so that the agility scores can be increased or help in creating additional responses that can make the overall adaptation process more agile. Being flexible and continuously engaging with stakeholders throughout the process also increases the accessibility and responsiveness among stakeholders. This can lead to the evolution of clumsy responses, i.e., adaptation responses which emerge from the local adaptation setting with outcomes that are beneficial and acceptable to all the stakeholders [12].

Simplicity of operational process: From the scoping exercise in Pune, it can be seen that a SWOT analysis and stakeholder mapping of the responses enabled the identification of the relationships and synergies between measures. Although the agility scores are qualitative, there is scope for developing a quantitative scoring method, similar to multiple benefits assessment tools (e.g., BeST [54]). Further identification of the leapfrogging potential is simple and can be guided using the principles of localising the SDGs [8].

Legitimising agile urban adaptation: Lack of motivation and ability among the stakeholders is considered as one the reasons for non-implementation of adaptation responses [21]. SDG initiatives offer motivation and a conducive environment for using agile urban adaptation, which can fast-track the achievement of SDGs. Agility offers the ability to stakeholders to implement adaptation responses in a quick and flexible manner [13]. Although agile adaptation is unlikely to create setbacks, changing frequently and too quickly could be seen as acting without clarity and lack of confidence by some of the stakeholders [55]. This might lead to the lack of political legitimacy and loss of mandate of the political and administrative authority. Policy backing for the agile adaptation process for the purpose of achieving SDGs will enhance its credibility. Agile urban adaptation will be more effective and assertive if it can secure political and institutional legitimacy. A comprehensive insight of resource allocation and timelines for planning, implementation, operation and maintenance of adaptation responses can be obtained through the analysis of the current, historical annual municipal budgets and annual audited statements. Assessing the responses from the aforementioned reports using the agility scorecard will help planning in advance for the next budget cycle, or in case there are special funds or grants which are lapsable.

Although it is theoretically possible to adapt short time steps such as in cycles of few weeks like in software development in an agile manner, we need to consider at least six months to one year lead time for approval and listing in the municipal budget. There are administrative and procedural hurdles in implementing response when they are not mentioned in the municipal budget for the planning year or approved by the municipal council. However, some of the adaptation responses can be implemented through approved actions such as operation and maintenance (O&M) of municipal assets. O&M is a broad budget head with no specific mention about locations or nature of interventions. The approved annual city budgets usually have considerable resources allocated for O&M, including retrofitting and replacement of assets, which can be utilised for agile implementation.

The scoping exercise in Pune reveals that working towards legitimacy might face little or no hindrance as agility can be practised using conventional adaptation responses within the existing urban institutional framework, i.e., the agility scores of agile elements of responses can be increased within the existing urban institutional framework. The legitimacy aspects can be further explored.

Relevance to sponge cities: The adaptation context and adaptation responses in Pune are comparable to that of sponge cities as sponge cites also aim at satisfying the adaptation deficits and adaptation needs, whereas the aspect of harmonising the deficits and need are not obvious. However, harmonising the adaptation deficits and needs is a necessity in sponge cities. Hence, it can be argued that the agile urban adaptation process is also valid and applied in the context of sponge cities. Also in case of sponge cities, planning and implementation of adaptation responses is left to cities although the overall guidance is from three central ministries [9]. The responsibility and ownership at city level for the planning and implementation of responses are ideal for the application of agile adaptation process, localisation and attainment of SDGs and the evolution of clumsy responses in sponge cities. City of Rotterdam in the Netherlands has some good examples in this regard, where there is a good coordination between various departments. For example the water department of Rotterdam proactively engages with other infrastructure departments whenever a major infrastructure change happens and tries to embed a water component as part of the change [56].

5. Conclusions

The paper focused on developing and testing a methodology to ascertain the scope for the operation of agile urban adaptation. The scoping exercise in Pune reveals that urban agile adaptation is not about implementing novel adaptation responses but planning and implementing the conventional adaptation responses in a different manner. For example, conventional adaptation responses such as city greening and check dams across the rivers have agile characteristics, these responses are synergetic with other adaptation responses and there is a possibility to compare conventional adaptation responses based on agile characteristics. Not doing different things but doing things differently, which also resonates well with the localising the SDGs in the cities [8] and can also pave way for legitimising the agile approach. Furthermore, the scoping exercise reveals the widely used SWOT analysis facilities mapping of synergies and relationships between the adaptation responses. Agility can help in realising the synergies between Type I and Type II adaptation needs and also enables leapfrogging towards sustainability. Furthermore, the scoping exercise and testing of agile adaptation in Pune synthesised important practical insights towards the application of scientific knowledge developed by Pathirana et al. [13]. This operational knowledge is crucial as focus on adaptation has started transitioning from planning to implementation of adaptation responses [6]. Hence, it is possible to apply the agile urban adaptation process using conventional adaptation responses in urban areas which address adaptation deficits related to infrastructure development as well as climate and socio-economic adaptation.

Acknowledgments: The authors would like to thank Pune Municipal Corporation, Non-governmental agencies, various agencies of the State Government of Maharashtra and Government of India for sharing the data and for the consultations.

Author Contributions: The paper is based on the results obtained from the research of Tejas M. Pathak, which was done for the partial fulfilment of requirements for the Master of Science degree at the IHE Delft Institute for Water Education under the supervision of Assela Pathirana, Mohanasundar Radhakrishnan and Keneth Irvine. The first draft was written by Mohanasundar Radhakrishnan and Tejas M. Pathak. Assela Pathriana and Keneth Irvine helped to review and improve the paper.

Conflicts of Interest: The authors declare no conflict of interest.

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