Capturing the changing dynamics between governmental actions across plausible future scenarios in urban water systems

Shanhong Wan, Mohanasundar Radhakrishnan*, Chris Zevenbergen, Assela Pathirana
IHE Delft Institute for Water Education, The Netherlands

Accepted version. Sustainable Cities and Society

Abstract

The paper discusses the need for a systematic approach based on SWOT analysis and DPSIR framework to establish and assess the connections between governmental actions that will ensure achieving water quality objectives at present and in the future scenarios. The proposed methodology to quantify the connection relies on impact based indicators for quantifying connections between governmental actions. The methodology was tested using the governmental actions usually implemented to improve water quality in Luzhi Town, a water village in China, in the context of four plausible scenarios based on change in land use and economic development. The results show that the connections between physical actions as well as policy actions change across future scenarios due to the change in drivers resulting in diverse impacts based on the scenario. For example, the difference in impact on water quality due to wetlands project is profound between the high green area scenarios and low green area scenarios irrespective of economic drivers, whereas the difference in impact due to the sanitation project is mild in all four scenarios. The connections between governmental actions across scenarios can be established and used by decision makers for resolving the challenges related to water quality deterioration in the future.

Keywords

Connections, DPSIR, Governmental actions, Scenarios, SWOT, Urban water systems, Water Quality

Introduction

Water quality is a big challenge for society today, the poor water quality can increase the health risk to the human beings, cause negative impacts to the ecosystem and hinder economic development (Emenike et al., 2017). As of Year 2015, globally only 39% people have access to safe and managed sanitation services, and 71% people have access to safe and managed drinking water services (United Nations, 2019). Based on the Chinese water quality standards for surface water: GB3838-2002, the proportion of sections in China with good water quality (I to III class) is 74.9%, the proportion of inferior V-class sections was 3.4%, based on chemical oxygen demand, total phosphorus and permanganate index (The Ministry of Ecology and Environment of China, 2020). Actions are taken by organisations at various levels which not only try address the water quality but also all the Sustainable Development Goals (SDGs) and emphasis is put on actions that aim to address more than one SDG (Radhakrishnan et al., 2017a). Achieving SDGs is a challenge due to looming uncertainties of drivers such as climate change, socio-economic change and political changes (Sadoff et al., 2020). For decision- makers, such as national or local government bodies, to know how the water situation can change is a big challenge as they need to consider future scenarios to take appropriate governmental actions to improve the current water quality as well as prevent the deterioration of water quality in the future.

Governments, such as the Japan and China, have changed their policy attitude from reactive to proactive water quality actions, such as making environmental protection policy, improving

the economic structure and industrial processing technology by making it sustainable and promote water recycling (Fang, 2016). The Chinese government has also initiated a number of measures to improve the water quality in the natural and urban environment. In 2015, the national government, approved sponge city project which aims at making all the Chinese cites act as a sponge to infiltrate, delay, store, clean, use and discharge water (The State Council of China, 2015a; Yuan et al., 2017). In the same year, the action plan for prevention and control of water pollution was published to determine the surface water quality objective (The State Council of China, 2015b). Also China implemented the river chief system to make the provincial, city, town and village governmental leaders responsible for the rivers and lakes within their scope of management (Liu et al., 2019). Those actions were aimed not only at the current water quality problems, but also try to prevent future problems. This is an effective administrative action to sustain water quality as the governmental leaders have motivation and abilities to carry out this task, which are very important for implementing adaptation actions (Nguyen et al., 2019).

There is consensus on the changing water quality due to the plausibility of multiple scenarios like climate change scenarios and socio- economic scenarios; and the need for targeted actions to ensure desired water quality (Mack et al., 2019; Molina-Navarro et al., 2020; Motew et al., 2019). However, the effect on water quality due to the improvement actions in future is uncertain and this can hamper decision making at a strategic or planning level whilst selecting the actions. Further knowledge about how these actions would ensure desired water quality in the future, either as individual actions or collectively, would resolve the difficulties during decision making. Hence, how to connect each action and how these connections can affect the implementation and functioning of these actions in the future would be a useful information to assess the feasibility of implementation of these actions at policy or programme level.

This paper puts forth a systematic approach to select the governmental actions that can ensure water quality based on the connection between governmental actions at present and in the future using Systems approach (Von Bertalanffy, 1968), SWOT analysis (Houben et al., 1999) and DPSIR framework (OECD, 2003). The proposed methodology under the ambit of systems approach employs: (i) SWOT analysis to identify the connections; and, (ii) DPSIR framework to quantify the connections using impact based indicators for connections between actions. The methodology has been tested using six governmental actions across four plausible future scenarios in Luzhi Town, a unique water village within Suzhou city, China.

Establishing and quantifying connections using impact based indicators

The selection of governmental actions to improve the water quality not only depends on the effectiveness of the action towards achieving the objectives but also on the capacity to adapt and sustain its effectiveness across a range of scenarios. Sustainability decision making encourages application of systems thinking to urban systems and to consider cities as system of systems (Davidson et al., 2011). A system is a complex network of elements interacting with themselves and its surrounding environment; and, system thinking combines various elements to connect them as a whole system (Von Bertalanffy, 1968). Hence the entire context can be analysed using systems approach to understand the governmental actions from an urban systems or whole systems perspectives to identify the connections between them like in the urban flood management contexts (Radhakrishnan et al., 2017b; Sayers et al., 2015). Also using the SWOT analysis in addition to system approach can lead to identification of more connections or better understanding of the connections between the actions and lead to performance based planning, which is sustainable (Botequilha-Leitão et al., 2020).

SWOT analysis, stands for strength, weakness, opportunity and threat, which is an easy is an open tool for the policymakers and decision makers to understand actions in a qualitative or quantitative manner, and to identify bottlenecks and synergies at system level (Houben et al., 1999; Islam et al., 2017; Jackson et al., 2003). Radhakrishnan et al. (2017a) have carried out SWOT analysis under the urban systems umbrella to identify the connections between actions addressing short term urban development and long term climate adaptation needs in Pune, India. The SWOT analysis in Pune done in consultation with multiple stakeholders and different perspectives lead to identification of more connections between actions. Radhakrishnan et al. (2017a) argue that the adaptation actions would perform well in the future scenarios, but have not explicitly mentioned or captured the change in connections across scenarios. The change in connections can be determined by performing a SWOT analysis for every scenario as the urban system and performance of actions are likely to be impacted by the different drivers or to a varying degree by the same set of drivers, such as climate change, socioeconomic pathways (SSPs) and other local factors (Jiang et al., 2017; Kc et al., 2017; O'Neill et al., 2017; O'Neill et al., 2014).

SWOT analysis for every future scenario would reveal the change in connections, i.e, the direction of impact and the possible change in bottlenecks and synergies. However the magnitude of impacts, i.e., quantification - either quantitatively or qualitatively, due to the change is still an unknown and is a knowledge gap, that can hinder decision making. Overcoming this knowledge gap will lead to informed decision making to facilitate the selection and implementation of projects. This can be done by analysing the relationship between two actions using DPSIR framework based on the anticipated impacts on water quality across space and time. Driver-Pressure-State-Impact-Response (DPSIR) is an analysis method based on systems thinking to analyse the effect and results of human activities (OECD, 2003). DPSIR is a strong tool for responding to actions and policies based on systems approach (Lewison et al., 2016). DPSIR analysis has been used to analyse a host of environmental problems, such as the impact of urbanisation, water management, sustainable development, land use, biodiversity and climate change (Haase et al., 2007; Tscherning et al., 2012). The response (R) is the specific action taken to ease the pressure and impact (Kaur et al., 2020), which in this case is the governmental action to reduce the adverse water quality impacts.

Connection between two actions can be determined by the pressure, state and impact in different scenarios that is strongly influenced by drivers. For example, when the action A is implemented, it can change the pressure on action B or the state of action B or state of the system through action B. Hence, the impact of action B can be affected by the change of state, which can be positive or negative or neutral. The connection from action A to action B can be different from the connection from action B to action A because of the different impact, which is due to changes in the pressure and state. An indicator can be used to represent the connection between two actions. Indicator is a quantitative, qualitative or binary variable that can be measured or described in response to a defined criterion (ISO 13065, 2015). The International Council for Science used a 7-points scale to quantify the qualitative nature of interactions between the 17 goals of SDGs (Griggs et al., 2017). Griggs et al. (2017) assigned a score between + 3 and -3 to the seven distinctive interactions among the SDGs namely indivisible, reinforcing, enabling, consistent, constraining, counteracting and cancelling. Similarly, the connection between the governmental actions can be represented by means of a qualitative or quantitative indicator based on the impact the action has on water quality. The indicator score can be assigned based on (i) measured or modelled water quality parameter or a set of water quality parameters such as the water quality guide line such as the Chinese water quality standards for surface water: GB3838-2002; or (ii) expert judgement done individually or with a group of stakeholders.

Methodology

A new methodology (Figure 1) titled “Impact based indicators for connections between governmental actions” has been formulated to ascertain the connections between the governmental actions that would improve the water quality in future scenarios.

(i) Action determination: Collate country wide as well as local policies and action that address the water quality as well as storm water management in the given context and detail out the attributes.
(ii) Action analysis in base scenario: Perform the SWOT analysis for each action. This results in a synergy map and also in a bottlenecks.
(iii) DPSIR analysis: Conduct DPSIR analysis for all actions in order to figure out the drivers, pressure, state, impact and how the responses, i.e. the actions relive the pressure on the system and reduce adverse impacts.
(iv) Scenario building: Select the drivers that are likely to play a dominant role in the future and build appropriate scenarios for the local context.
(v) Action analysis in future scenarios: Repeat steps (ii) and (iii), the SWOT and DPSIR analysis, but after understanding the differences in implementation conditions in different scenarios.
(vi) Quantifying the connections: The connections between the two governmental actions is quantified using the indictor score based on the impact of the action on the water quality in the base and future scenarios, which is the outcome of DPSIR analysis.

This methodology has been tested in the context of water quality improvement for Luzhi town in Suzhou City, China.

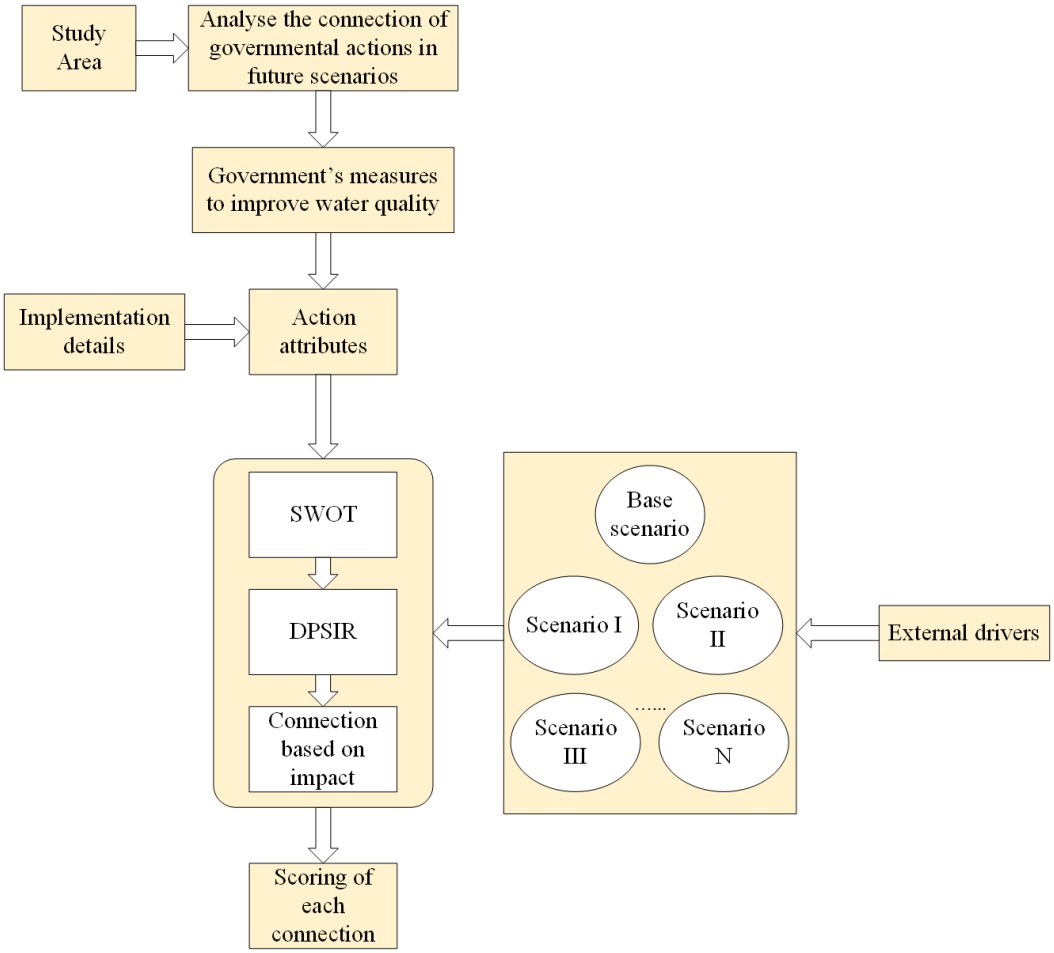


Figure 1 Methodology: Impact based indicators for connections between governmental actions

Case study application

Luzhi Town is a typical ancient water village in China with complex water system network, that has a rich cultural significance. Manufacturing industries and tourism are the primary and secondary source of income for Luzhi town respectively, which is witnessing the increase in numner of tourists every year (The People's Government of Luzhi Town, 2020; The Tourism Department of Suzhou, 2013). The industrial and tourism activities also negatively impact the water quality and has lead to the planning or implemenation of water quality improvement actions by the local government (Liu et al., 2019; The Housing and Urban-rural Development Department of Luzhi Town, 2019; The Planning Department of Suzhou, 2017; The State Council of China, 2014). Of these governemntal actions, six actions namely the flood protection project, sewerage project, sanitation project, river chief system, river network system improvement and wetland construction were slected to ascertain the connections between them. The salient features about these actions the stakeholders involved in these projects are shown in Figure 2. More details about these six actions and information about water quality tests and public opinion about government actions in general are presented as supplementary materials in Annex A.

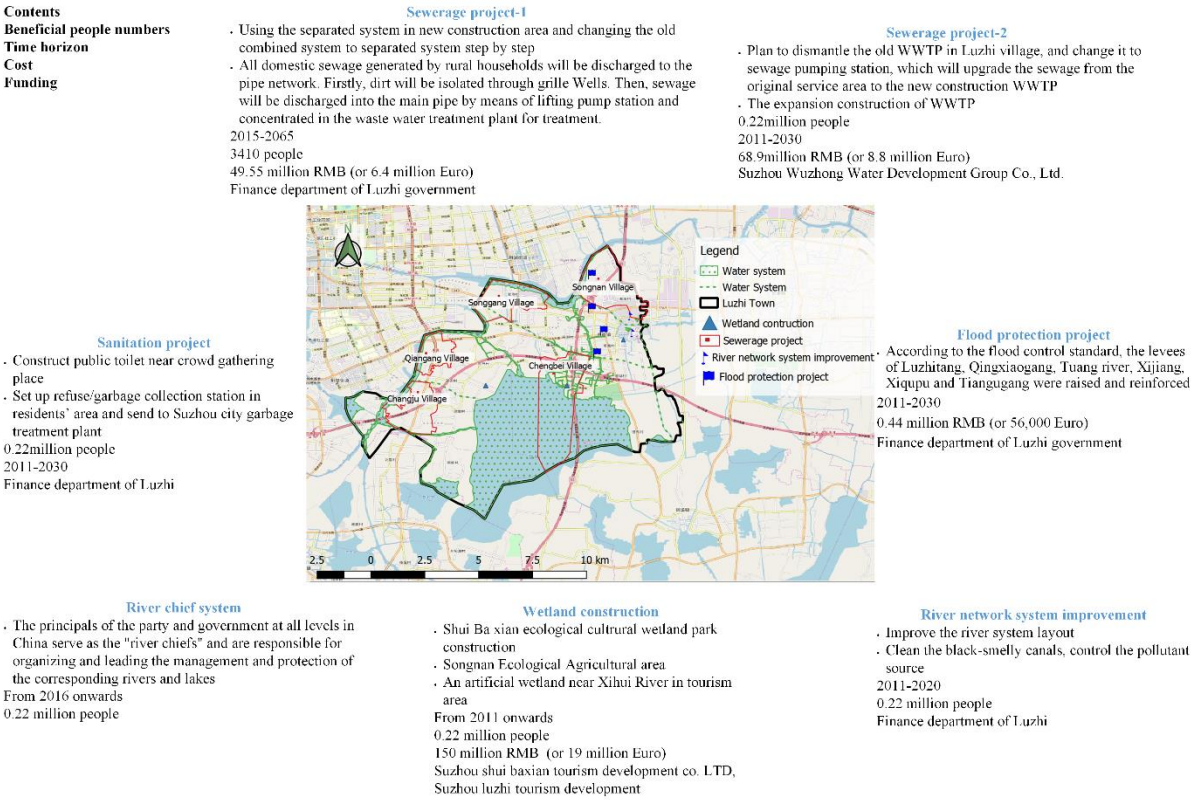


Figure 2 Details of governmental actions

Understanding the salient features of the actions and the stakeholders involved in the actions facilitated the SWOT analysis, such as the SWOT analysis of the "Flood protection project presented in Table 1. The SWOT analysis of all the six actions in base scenario - presented as supplementary materials in Annex A - reveals the synergy, bottleneck and the connections between the actions. The synergies and bottleneck map of base scenario are shown in Figure 3 and Figure 4. Understanding the ground reality at Luzhi village with respect to water quality through frequent field visits; water quality testing of surface waterbody at critical location; and, assessment of residents and tourist perception through surveys by the first author between Oct 2019 and Jan 2019 were helpful in arriving at expert judgements during the SWOT and DPSIR analysis.

Table 1 SWOT analysis of flood protection project

Strength	**Opportunity**
• Make use of existing facilities, easy to manage • Low cost	• Change the land use type • Detention and flood storage
Weakness	**Threat**
• Conditions of existing facilities such as dams and dikes are not known, which may have weak flood protection	• Cannot cover all the village area, so it can bring some threat to the unprotected area • Have some negative impact for detention basin

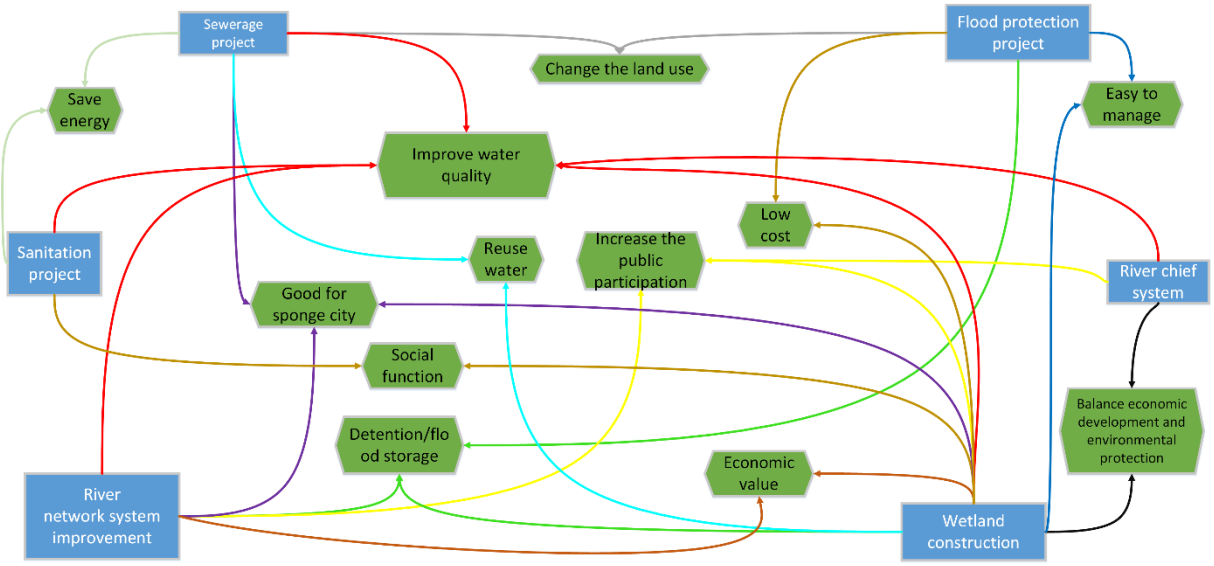


Figure 3 synergies map of base scenario

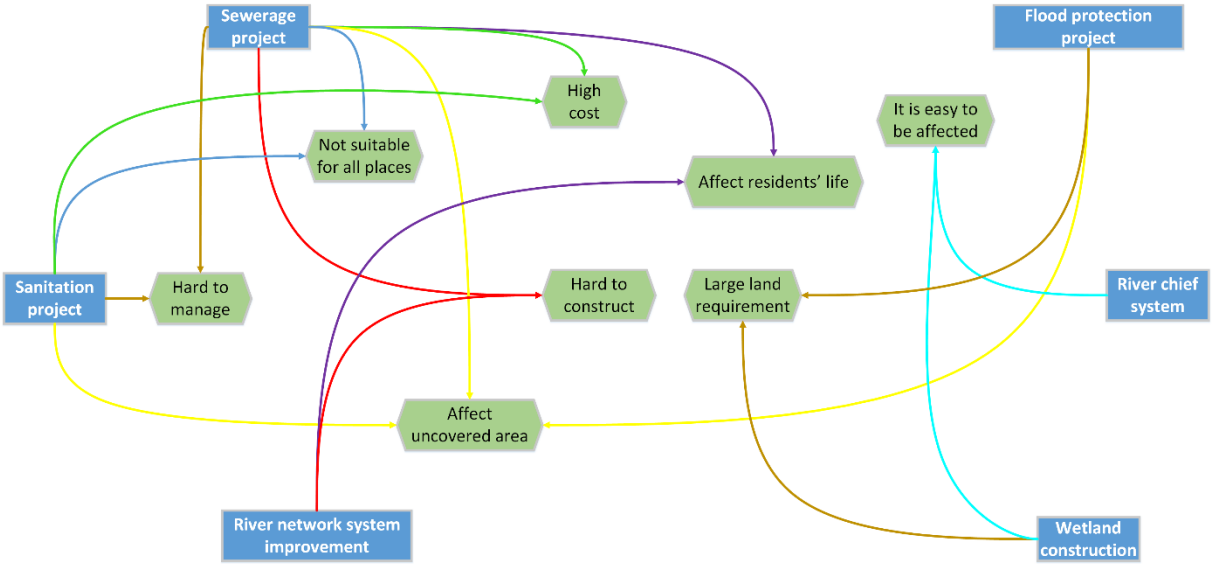


Figure 4 Bottlenecks map of base scenario

The DPSIR analysis forms the basis for water quality impact indicator score. The DPSIR analysis of the "Flood protection project" response or action is as follows: Driver – Climate change; pressure – rainfall; state – there are water logging conditions at present as the flood existing protection and drainage requirements are inadequate; impact: the whole faces flood risk; and, response – flood protection project. The DPSIR analysis of all the six actions in base scenario is presented as supplementary material as Annex A. The DPSIR analysis in the base scenario revealed the following drivers: economic level, economic dependence, public awareness, technology, land use, pipe system, the ratio of domestic sewage and industrial sewage, climate change, tourism, population, urbanisation, and hydraulics. Based on the Luzhi context the economic dependence emerged as the major driver and is likely to be influenced either by manufacturing industry or by tourism in the future. Also green land use is another major driver as sponge cities projects are likely to be implemented at large scale in the next 10 years across China (Griffiths et al., 2020). Based on these two drivers the following four scenarios were considered for analysis of the connections between actions: Scenario I – Tourism based economy in a high green area; Scenario II – Tourism based economy in a low

green area; Scenario III – Heavy industry based economy in a low green area; and Scenario IV – Heavy industry based economy in a high green area. SWOT analysis of actions revealed the connections and the changes between the actions in these scenarios. For example, the large green area offers enough green space for storm water to store and delay in scenario I and IV, which can decrease the pressure on the flood protection project, whereas the presence of less green areas in scenario II and III can increase the pressure on it. The detailed SWOT analysis of all the actions are presented as supplementary details as Annex B. A brief summary of impacts due to governmental actions in Luzhi village across scenarios based on expert judgement is presented in Table 3.

Using expert judgement, one of the five qualitative value - such as strongly negative, negative, no impact, positive and strongly positive - were assigned to the connections between the actions based on the anticipated temporal and spatial water quality impacts. A 5-points scale indicator ranging between -2 to +2 was used to quantify the qualitative nature of connections (Table 2). It should be noted that the modelling of water quality parameters or assigning the indicator scores in consultation with a group of stakeholders might have resulted in a different indicator score. The water quality impact based indicators for connections between governmental actions across the four future scenarios is shown as Figure 5.

Table 2 Quantitative Indicators for connections between governmental actions based on the nature and strength of impacts

Indicator *f*(Impact)	Criteria: Nature and strength of Impact	Definition or Justification
-2	Strongly Negative	Deterioration of water quality at all times or in all places
-1	Negative	Deterioration of water quality in a specific time or a place
0	No impact	No impact to the water quality
+1	Positive	Improvement to the water quality in a specific time or place
+2	Strongly positive	Improvement the water quality at all times or in all places

The sum of indicator scores of connection between the actions in the all the four scenarios is presented in Table 4. The change in sum of indicator score for each action across scenarios can be noticed. The indicator score between each set of actions in the base scenario and in all the four scenarios are presented as supplementary material in Annex C and Annex D.

Table 3 Summary of overall impacts due to governmental actions in Luzi village across scenarios based on expert judgement

Scenario II – Low green area and economic dependence on tourism • The small green area limits the scope for water quality improvement and is a concern for the river chief. • The increasing water use which is caused by tourism development and lack of the green area is a big challenge for sewage treatment process. • In the flood protection project, the small green area cannot delay and store storm water and water quality downstream might be affected. • The public sanitation facilities meet the requirements of tourism development and prevents contamination of open water bodies • The small green area does not have enough space for the wetland, which also has little possibility for the tourists visiting. The river network system improvement project contributes to clean the water, which improves tourist experience.	**Scenario I - High green area and economic dependence on tourism** • The river chief can balance the economic development and environmental protection as good environment is the key point in tourism development. • The increasing water use due to tourism development is also a big challenge for the sewage treatment plant, but can benefit from using the large green area. • The large green area offers enough space for storm water delay and storage, which can decrease the pressure on the flood protection project. • The public sanitation facilities meet the requirements of tourism development and prevents contamination of open water bodies • The large green land use allocation has enough space for the wetland. In addition, the wetland can also be a place for the tourists to visit. • The river network system improvement project contributes to clean the water, which improves tourist experience.
Scenario III – Low green area and economic dependence on heavy industry • The small green area limits the scope for water quality improvement and increased industrial activity can worsen it, a concern for the river chief. • The sewerage project will have to remove the pollutants from the industrial waste water, and have to depend heavily upon conventional chemical treatment process. And some unpermitted private pipe connections of industry can cause high pollution in the river. • In the flood protection project, the small green area cannot delay and store storm water and water quality downstream might be affected. • The small green area does not have enough space for the wetland, and it is hard to improve the surrounding industrial environment. • The small green areas and increased industrial activities may not yield sustainable results on river network system improvement.	**Scenario IV- High green area and economic dependence on heavy industry** • Bad water quality due to heavy industry is concern for river chief, but the large green area can help in water quality improvement. • The sewerage project will have to remove the pollutants from the industrial waste water, and have to depend heavily upon conventional chemical treatment process in spite of large of the green area. And some unpermitted private pipe connections of industry can cause high pollution in the river. • The large green area offers enough space for storm water delay and storage, which can decrease the pressure on the flood protection project. • The large green land have enough space for the wetland, which is also good to improve the surrounding environment of the industry. • Increased industrial activities may not yield sustainable results on river network system improvement. But the large green area can increase the ability of self-purification in the river.

Table 4 The sum of connection in different scenarios

	Flood protection project	Sewerage project	Sanitation project	River chief system	River network system improvement	Wetland construction
Base scenario	5	7	6	8	5	9
Scenario I	1	5	3	9	4	8
Scenario II	5	6	0	8	2	-2
Scenario III	5	4	7	7	2	-2
Scenario IV	1	4	5	8	5	8
Sum of connection in future scenarios	12	19	15	32	13	12

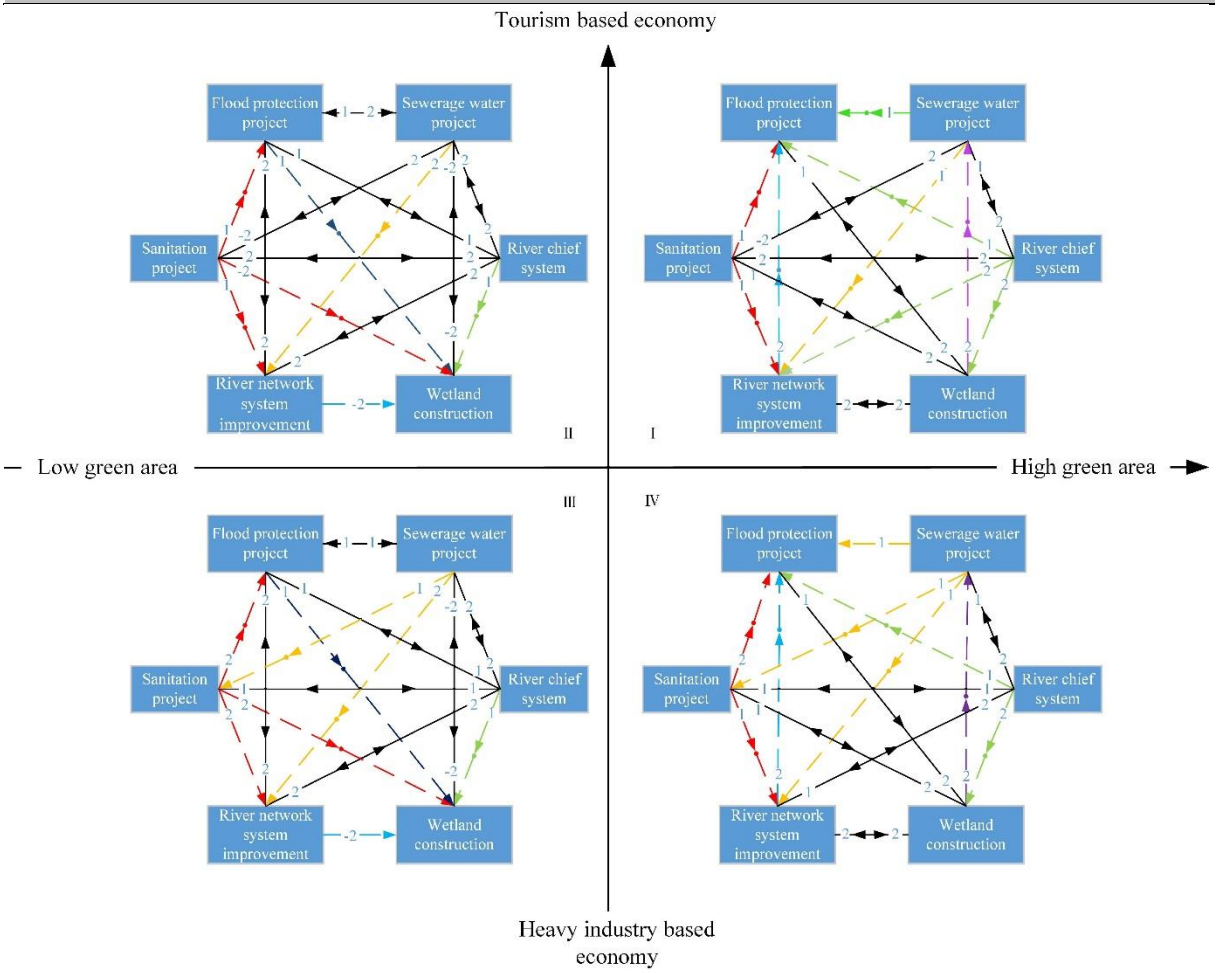


Figure 5 Quantification of connections between governmental actions across future scenarios (the lines between actions represent the connections, the black continuous lines represent a two way connection, the coloured lines represent the one way connection, the numbers along lines represent the impact indicator score)

Discussion

From the results, it is evident that combining SWOT analysis and DPSIR framework for urban systems analysis across scenarios will reveal the hidden and changing nature of connections. can work together to be a systematic approach to select governmental actions based on the

connection between the current actions. In case of Luzhi village, through the impact scores, it can be seen that the connections can change in different scenarios when the drivers are changing. From Table 4 it can be seen that the sum connections between the actions are not the same across all the scenarios, such as in case of sanitation project. Also it can be noticed that the some actions have the same impact scores in certain scenarios, such as flood protection and wetland actions. Flood protection has an impact score of 1 in scenarios I and IV; and a score of 5 in scenarios II and III. Wetland has an impact score of 8 in scenarios I and IV; and a score of -2 in scenarios II and III. It can stated that the wetland performs better in scenarios I and IV where more green area is available, whereas flood protection performs better in scenario II and III. It should there can also be no changes in the individual impact score between some actions across scenarios as evident from the connection between River chief and River network improvement project which has the maximum impact score of 2 in all the scenarios (Figure 5). Also drastic change in the impact scores of all actions except sanitation project can be noticed between scenarios I and II, I and III, II and IV, and III and IV. This leads to the conclusion that availability of green area is the dominant driver across the scenarios for most actions in Luzhi village. In case of sanitation project the economic driver is the dominant driver across scenarios.

It can be inferred that the change in drivers can influence the implementation and performance of actions leading to varying impacts in future scenarios. Understanding this change of connection between actions can help the decision makers to select appropriate actions from a set of actions or to arrive at a sequence of implementation. The order of priority for implementation or deliberation can be based the on the sum of impact scores across the scenarios. The action with a higher score given the top priority, river chief system in this case, and, the action with the lowermost score given the least priority i.e., the flood protection project. In addition, across the four scenarios, not only does the score change, the nature of relationship also change between some actions. For example, the connection between flood protection project and sewerage project is two way in scenario II and III, whereas the relationship is one way in scenario I and IV. Presence of large green area can help to delaying or prevention of the flood waters and the floods would not affect the sewerage project by causing overflow. Hence the construction of flood protection protect has no impact to the sewerage project, as well as the water quality in scenario I and IV. On the contrary, the absence of green area cannot help in delaying floodwater, which makes that the construction of flood protection project will have positive impact on the sewerage project, as well as the water quality in scenario II and scenario III.

The analysis also reveals the system level changes in synergies and bottlenecks across scenarios and paves way for actions to be modified in order to maximise the synergies and minimise the bottlenecks across the scenarios. Analysing the changing connections between scenario I and II reveals the synergy between balancing economic development through tourism and environmental protection of green areas using the good offices of the river chief system. Also through river chief system there is scope for synergising economic development and environmental benefits across scenarios I and II by exploring cash crop cultivation using wetlands. Also a new bottle neck crops up across scenarios III and IV which is the difficulty in balancing economic development and environmental protection as the economic dependence in these scenarios is dependent the heavy industry. This would necessitate adjustments in planning and implementation of the river chief system and wetland construction to minimise this bottleneck. Thus the SWOT and DPSIR analysis based impact scores can facilitate informed decision making at policy, strategic and planning level; and can also help in creating better narratives or stories to understand the impact of actions across scenarios.

Also the SWOT-DPSIR analysis of actions across scenarios reveal the connections and dynamics between actions of different nature. Of these six action analysis five of these actions

are physical action that are traditional engineering or ecological in nature, such as sewage project or such as constructed wetlands, whereas the river chief system is a policy driven administrative action. It is difficult to capture the dynamics in the relationship between physical actions and administrative actions using mathematical models. The analysis here reveals that the interconnections between river chief system and other action across scenarios are strong, consistent and important (Table 4). Also this a testimony or a confirmation of the fact that the impact of policy or administrative actions on physical actions are most likely, higher and visible and not vice versa (Chu et al., 2017).

This impact based indicator methodology using DPSIR framework and SWOT analysis in urban context can be used to quantify the connection between governmental actions of sponge city projects in China, which comprises physical actions and policy actions. Although the overall guidance is from the central government of China, the local government also has the power to plan and has responsibility for the possible outcomes (The State Council of China, 2015a). With respect to sponge city project climate, geology and socio-economic factors seem to influence the way that national guidelines are implemented; whereas project financing, integration and assessment are found to be of increasing influencing at local level (Griffiths et al., 2020). Hence the impact on project financing, integration and assessment drivers due to connection between sponge city action can be used to assed across scenarios such as high/ low climate change with fast or medium or slow socio-economic changes. Analytic hierarchy process–AHP (Saaty, 1977; Velmurugan et al., 2011) are being used in the ongoing efforts which aim at evaluating effectiveness of pairs of blue-green infrastructure actions towards achieving the Sponge city project objectives. The impact based indicator methodology will complement such approaches and can also benefit from these approaches by adopting the ranking techniques for action pairs used in these approaches.

The methodology suggested in this paper can be used to capture the change in connections between same actions: (ii) in two different contexts such as top-down and bottom up contexts which are prevalent in urban adaptation contexts (e.g. Chu et al. (2017)); (ii) from a motivation and abilities perspective of stakeholders involved (e.g. Nguyen et al. (2019)); (iii) to arrive at an optimal implementation prioritisation ranking of actions that can effectively adapt to changing circumstances (e.g. Radhakrishnan et al. (2018)). The multiple perspectives from different stakeholders can help in better understanding the synergies and bottlenecks (Radhakrishnan et al., 2017b). The expert judgement of impacts would have yielded better results if stakeholders such as governmental staff, operational staff and residents were consulted in making the SWOT and DPSIR analysis, making it comprehensive. This was not possible due to some practical difficulties and getting permissions for the one to one interviews. Opinions will not be aired publically, especially in China, due to cultural reason resulting in a round table format multi-stakeholder consultation expressing the opinion of the most powerful stakeholder (Bilalić et al., 2008). Also it is worth considering this methodology to assess the attainability of the SDG's through every action in future scenarios. For example River chief systems can contribute to a greater extent to SDG 11 (sustainable cities); SDG 13 (Climate action); SDG 14 (Life below water), SDG 15 (Life on land) and SDG 17 (Partnerships) in a larger green area scenario in Luzhi village. However the contribution of River chief systems would limit itself to SDG 11 (sustainable cities) and SDG 17 (Partnerships) in a smaller green land scenario. Also it is recommended to change the 5- point indicator used here to the 7-point indicator used by Griggs et al. (2017) so that the impact indicators are in line with the interconnection indicators used in the context of SDGs, which also avoids multiplicity of criteria's. Hence we see that there is a scope to carry forward this research beyond the water quality domain of urban systems and expand the application of this methodology.

Conclusion

The paper discussed the need for a systematic approach based on SWOT analysis and DPSIR framework to establish and assess the connections between governmental actions that will ensure achieving water quality objectives at present and in the future scenarios. The proposed methodology to quantify the connection relied on impact based indicators for quantifying connections between governmental actions. SWOT analysis and DPSIR frameworks were used to identify the connections between the actions, synergies and bottlenecks while achieving the water quality objectives at the system level at various scenarios. Upon application in Luzhi town in Shuzou city, China the methodology helped in assessing and identifying: the connections between six different and government actions; the change in connections between the actions across scenarios; and, the change in system impact due to the change in connections between actions across scenarios and quantifying the same. This assessment created additional knowledge about the performance and behaviour of the governmental actions across scenarios towards achieving the desired water quality objective. Also the approach has demonstrated that possibility to clearly establish and quantify the connection between a policy and physical action; and the dynamics of the connection across scenarios. This information can be of help to the decision makers at the policy, programmatic and planning domain to select or prioritise actions what would ensure achieving water quality objectives at present and in the future scenarios. Further the proposed systematic approach based on SWOT analysis and DPSIR framework can be improved and used in other contexts to achieve other objectives, such as achieving one or more SDGS in an urban context, where multiple actions are involved and their performance likely to vary in future. It can be concluded that by combining SWOT analysis and DPSIR framework, the connections between governmental actions can be established; and, scenario-based impact assessment methods can be used to select, implement and sustain governmental actions for resolving the challenges related to water quality deterioration in the future.

References

Bilalić, M., McLeod, P., & Gobet, F. (2008). Why good thoughts block better ones: The mechanism of the pernicious Einstellung (set) effect. *Cognition, 108*(3), 652-661.

Botequilha-Leitão, A., & Díaz-Varela, E. R. (2020). Performance Based Planning of complex urban social-ecological systems: The quest for sustainability through the promotion of resilience. *Sustainable Cities and Society, 56*, 102089. doi:https://doi.org/10.1016/j.scs.2020.102089

Chu, E., Anguelovski, I., & Roberts, D. (2017). Climate adaptation as strategic urbanism: assessing opportunities and uncertainties for equity and inclusive development in cities. *Cities, 60, Part A*, 378-387. doi:http://dx.doi.org/10.1016/j.cities.2016.10.016

Davidson, K. M., & Venning, J. (2011). Sustainability decision-making frameworks and the application of systems thinking: an urban context. *Local Environment, 16*(3), 213-228. doi:10.1080/13549839.2011.565464

Emenike, C. P., Tenebe, I. T., Omole, D. O., Ngene, B. U., Oniemayin, B. I., Maxwell, O., & Onoka, B. I. (2017). Accessing safe drinking water in sub-Saharan Africa: Issues and challenges in South–West Nigeria. *Sustainable Cities and Society, 30*, 263-272. doi:https://doi.org/10.1016/j.scs.2017.01.005

Fang, H. (2016). *Research on the development process of water environment treatment in Japan(日本水环境治理的发展历程研究)*. Paper presented at the Proceedings of the 8th National Forum on River and Lake Governance and Aquatic Civilization Development in 2016, Beijing, China.

Griffiths, J., Chan, F. K. S., Shao, M., Zhu, F., & Higgitt, D. L. (2020). Interpretation and application of Sponge City guidelines in China. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 378*(2168), 20190222. doi:doi:10.1098/rsta.2019.0222

Griggs, D. J., Nilsson, M., Stevance, A., & McCollum, D. (2017). *A guide to SDG interconnections from science to implementation*. Retrieved from Paris:

Haase, D., & Nuissl, H. (2007). Does urban sprawl drive changes in the water balance and policy?: The case of Leipzig (Germany) 1870–2003. *Landscape and Urban Planning, 80*(1-2), 1-13.

Houben, G., Lenie, K., & Vanhoof, K. (1999). A knowledge-based SWOT-analysis system as an instrument for strategic planning in small and medium sized enterprises. *Decision Support Systems, 26*(2), 125-135. doi:https://doi.org/10.1016/S0167-9236(99)00024-X

Islam, F., & Mamun, K. (2017). Possibilities and challenges of implementing renewable energy in the light of PESTLE & SWOT analyses for island countries. In *Smart Energy Grid Design for Island Countries* (pp. 1-19): Springer.

ISO 13065. (2015). Sustainability criteria for bioenergy. In (pp. 1-65). Geneva, Switzerland: International Organization for Standardization,.

Jackson, S. E., Joshi, A., & Erhardt, N. L. (2003). Recent research on team and organizational diversity: SWOT analysis and implications. *Journal of Management, 29*(6), 801-830. doi:https://doi.org/10.1016/S0149-2063(03)00080-1

Jiang, L., & O'Neill, B. C. (2017). Global urbanization projections for the Shared Socioeconomic Pathways. *Global Environmental Change, 42*, 193-199. doi:https://doi.org/10.1016/j.gloenvcha.2015.03.008

Kaur, M., Hewage, K., & Sadiq, R. (2020). Investigating the impacts of urban densification on buried water infrastructure through DPSIR framework. *Journal of Cleaner Production, 259*, 120897. doi:https://doi.org/10.1016/j.jclepro.2020.120897

Kc, S., & Lutz, W. (2017). The human core of the shared socioeconomic pathways: Population scenarios by age, sex and level of education for all countries to 2100. *Global Environmental Change, 42*, 181-192. doi:https://doi.org/10.1016/j.gloenvcha.2014.06.004

Lewison, R. L., Rudd, M. A., Al-Hayek, W., Baldwin, C., Beger, M., Lieske, S. N., . . . Hines, E. (2016). How the DPSIR framework can be used for structuring problems and facilitating empirical research in coastal systems. *Environmental Science & Policy, 56*, 110-119.

Liu, H., Chen, Y. D., Liu, T., & Lin, L. (2019). The River chief system and river pollution control in China: a case study of Foshan. *Water, 11*(8), 1606. Retrieved from https://www.mdpi.com/2073-4441/11/8/1606

Mack, L., Andersen, H. E., Beklioğlu, M., Bucak, T., Couture, R.-M., Cremona, F., . . . Birk, S. (2019). The future depends on what we do today – Projecting Europe's surface water quality into three different future scenarios. *Science of The Total Environment, 668*, 470-484. doi:https://doi.org/10.1016/j.scitotenv.2019.02.251

Molina-Navarro, E., Segurado, P., Branco, P., Almeida, C., & Andersen, H. E. (2020). Predicting the ecological status of rivers and streams under different climatic and socioeconomic scenarios using Bayesian Belief Networks. *Limnologica, 80*, 125742. doi:https://doi.org/10.1016/j.limno.2019.125742

Motew, M., Chen, X., Carpenter, S. R., Booth, E. G., Seifert, J., Qiu, J., . . . Kucharik, C. J. (2019). Comparing the effects of climate and land use on surface water quality using future watershed scenarios. *Science of The Total Environment, 693*, 133484. doi:https://doi.org/10.1016/j.scitotenv.2019.07.290

Nguyen, H. Q., Radhakrishnan, M., Bui, T. K. N., Tran, D. D., Ho, L. P., Tong, V. T., . . . Ho, H. L. (2019). Evaluation of retrofitting responses to urban flood risk in Ho Chi Minh City using the Motivation and Ability (MOTA) framework. *Sustainable Cities and Society, 47*, 101465. doi:https://doi.org/10.1016/j.scs.2019.101465

O'Neill, B. C., Kriegler, E., Ebi, K. L., Kemp-Benedict, E., Riahi, K., Rothman, D. S., . . . Solecki, W. (2017). The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. *Global Environmental Change, 42*, 169-180. doi:https://doi.org/10.1016/j.gloenvcha.2015.01.004

O'Neill, B. C., Kriegler, E., Riahi, K., Ebi, K. L., Hallegatte, S., Carter, T. R., . . . van Vuuren, D. P. (2014). A new scenario framework for climate change research: the concept of shared socioeconomic pathways. *Climatic Change, 122*(3), 387-400. doi:10.1007/s10584-013-0905-2

OECD. (2003). *OECD Environmental Indicators: Development, measurement and use*. Retrieved from Paris: http://www.oecd.org/environment/indicators-modelling-outlooks/24993546.pdf

Radhakrishnan, M., Islam, T., Ashley, R. M., Pathirana, A., Quan, N. H., Gersonius, B., & Zevenbergen, C. (2018). Context specific adaptation grammars for climate adaptation in urban areas.

Environmental Modelling & Software, 102, 73-83. doi:https://doi.org/10.1016/j.envsoft.2017.12.016

Radhakrishnan, M., Pathak, T. M., Irvine, K., & Pathirana, A. (2017a). Scoping for the Operation of Agile Urban Adaptation for Secondary Cities of the Global South: Possibilities in Pune, India. *Water, 9*(12), 939.

Radhakrishnan, M., Pathirana, A., Ashley, R., & Zevenbergen, C. (2017b). Structuring climate adaptation through multiple perspectives: framework and case study on flood risk management. *Water, 9*(2). doi:10.3390/w9020129

Saaty, T. L. (1977). A scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology, 15*(3), 234-281. doi:https://doi.org/10.1016/0022-2496(77)90033-5

Sadoff, C. W., Borgomeo, E., & Uhlenbrook, S. (2020). Rethinking water for SDG 6. *Nature Sustainability, 3*(5), 346-347. doi:10.1038/s41893-020-0530-9

Sayers, P., Galloway, G., Penning-Rowsell, E., Yuanyuan, L., Fuxin, S., Yiwei, C., . . . Guan, Y. (2015). Strategic flood management: ten 'golden rules' to guide a sound approach. *International Journal of River Basin Management, 13*(2), 137-151. doi:10.1080/15715124.2014.902378

The Housing and Urban-rural Development Department of Luzhi Town. (2019). Information on the bidding project of the rural sewage treatment project of luzhi Village in 2019(角直镇 2019 年农村生活污水治理工程). *Notice.* Retrieved from http://www.suzhou.gov.cn/szsrmzf/jsxmztbqk/201910/0BG77BYFFBGH83MCCSOKKTN2D5EMZXQF.shtml

The Ministry of Ecology and Environment of China. (2020). *State of surface water and air quality in China in 2019(2019 年全国地表水、环境空气质量状况)*. Beijing: the Ministry of Ecology and Environment of the RPC, Retrieved from http://www.mee.gov.cn/hjzl/shj/qgdbszlzk/202002/P020200220742981170464.pdf

The People's Government of Luzhi Town. (2020). Report of governmental work in 2019 (2019 年政府工作报告). *Administrative information.* Retrieved from http://www.szwz.gov.cn/zwgk/003011/003011002/20191230/ec1cfc86-000a-4111-b691-fda9e2bffcbe.html

The Planning Department of Suzhou. (2017). *Regulatory plan of luzhi Village, Suzhou (2011-2030) (revised in 2016)(苏州市角直镇总体规划（2011－2030 年）（2016 年修改）)*. Retrieved from http://www.zfxxgk.suzhou.gov.cn/sjjg/szsghj/201708/t20170801_892964.html

The State Council of China. (2014). *National new urbanization plan (2014-2020)*. Beijing, China Retrieved from http://www.gov.cn/zhengce/2014-03/16/content_2640075.htm

The State Council of China. (2015a). *Guiding opinions of the general office of the state council on promoting the construction of the sponge city*. (000014349 / 2015-00168). Beijing, China Retrieved from http://www.gov.cn/zhengce/content/2015-10/16/content_10228.htm

The State Council of China. (2015b). *Notice of the State Council on printing and distributing action plans for the prevention and control of water pollution*. Bejing, China: State Council Retrieved from http://www.gov.cn/zhengce/content/2015-04/16/content_9613.htm

The Tourism Department of Suzhou. (2013). *Suzhou tourism annual report*. Suzhou, China: The Tourism Department of Suzhou

Tscherning, K., Helming, K., Krippner, B., Sieber, S., & Paloma, S. G. y. (2012). Does research applying the DPSIR framework support decision making? *Land Use Policy, 29*(1), 102-110. doi:https://doi.org/10.1016/j.landusepol.2011.05.009

United Nations. (2019). *Special edition: progress towards the sustainable development goals*. Retrieved from

Velmurugan, R., Selvamuthukumar, S., & Manavalan, R. (2011). Multi criteria decision making to select the suitable method for the preparation of nanoparticles using an analytical hierarchy process. *Die Pharmazie - An International Journal of Pharmaceutical Sciences, 66*(11), 836-842. doi:10.1691/ph.2011.1034

Von Bertalanffy, L. (1968). *General system theory: Foundations, Development, Applications*. New York: George Braziller Inc.

Yuan, Z., Liang, C., & Li, D. (2017). Progress and prospect of the study on sponge city in China. *Ecology and Environmental Sciences, 26*(5), 896-901.

Supplementary materials

This supplementary section contains:

1. Water quality, details of the government actions planned in Luzhi village, SWOT analysis of actions in base scenario and establishment of DPSIR framework in the context of water quality (Annex A);
2. SWOT analysis of actions in future scenarios (Annex B);
3. Impact based indicators for connection between actions through DPSIR analysis of all the actions on water quality in base and future scenarios (Annex C); and
4. The synergy maps, bottle neck maps, interconnection impact indictor scores and relationship maps between all the actions in base and future scenarios (Annex D)

These details form the basis for the determination of relationship between the six government actions across scenarios and the interconnection impact indicator scores based on water quality in the scenarios. It should be noted that that SWOT analysis, DPSIR and interconnection scores are based on the expert judgement of the first author based on the first author's field experience in Luzhi village and expert judgement under the supervision of the second and third authors.

Annex A. Analysis of government actions in base scenario

Surface water quality and perceptions about water quality in Luzhi village

The water quality data of Luzhi Town is not publicly available. Fragmented water quality data can be retrieved from scientific papers, interviews with local residents, shop owners and tourists and some simple water quality tests are providing important additional information on the current water quality status of Luzhi Town.

Jia et al. (2013) conducted 11 hydrologic surveys in 22 sections, measuring DO, NH_3-N, BOD_5 and flow rates from 2008 to 2010. Based on the Chinese water quality standard for surface water (GB3838-2002), in the water quality monitoring of Luzhi River network, the flow rates of about 73% rivers were slower than 0.05m/s. The 3 indexes of DO, NH_3-N, BOD_5 are 36%, 29% and 66% respectively, which were worse than Ⅳ-class standard, among which, 21%, 38% and 12% were worse than Ⅴ-class standard. It shows that most of the river sections were in a bad stage for a long time. What's more, those rivers with low discharge rate had bad water quality. Y. Li et al. (2014) showed that the water body of Luzhi Town presented N/P and organic pollution, and presented Ⅳ-class and Ⅴ-class water standards.

Interviews were conducted on data in Luzhi Town. For the interviews, there are 11 closed questions and 3 open questions. Table 0-1bsummarizes the results of the interviews with the residents, shop owners and tourists. The table reflects their perception about the current water quality and how the people think about the government's actions to improve the water quality. It also discloses whether the current water quality affects their daily life and tourism feeling.

Table 0-1 The result of interview

Questions	**Residents' attitude**				
	Strongly agree	Agree	No idea	Oppose	Strongly oppose
Tourism development increase the local economic level	17%	72%	11%	0	0
Water quality decline since tourism developed (from 2003 year?)	17%	33%	39%	11%	0
The surrounding infrastructure (public toilets, trash cans, etc.) is very good	33%	50%	0	17%	0
Water quality decline can have negative impact on tourism	11%	56%	22%	11%	0
Water quality decline can have negative impact on surrounding residential environment	17%	60%	17%	6%	0
Daily water utilization custom and style have changed	0	45%	33%	22%	0
Residents' life quality declined	0	22%	33%	45%	0
Water quality decline can have negative impacts on the ecological environment	22%	50%	22%	6%	0
Government make some measures to improve the water quality	6%	56%	22%	11%	5%
After government' measures, the water quality improve a lot	0	50%	22%	17%	11%
The water quality can become better in the future	11%	33%	39%	17%	0
Would you please rate your satisfaction with the water quality of the canal?(1-10, the higher the number, the higher the satisfaction)	Score	Interviewee's number		Result	
	1	0		0	
	2	3		6%	
	3	6		11%	
	4	6		11%	
	5	18		33%	
	6	12		22%	
	7	3		6%	
	8	6		11%	
	9	0		0	
	10	0		0	
What do you think is the main role in improving the water quality?	Government:67% Scenic area department:11% Tourist:16% Other:44%				
What may affect the water quality in the canal?	Shop, domestic waste, restaurant, impolite behaviours, industry				
Do you have any suggestions to improve the water quality?	Governmental manage, separation system, clean the canal sludge, don't throw the garbage into the canal directly				

For the water quality test, five points were chosen (Figure 0-1): two points are in the tourist area, one point is in the polluted river with foul odour, one point is in the industrial park, and the last one downstream of tourist area. Only the ammonia nitrogen content and total phosphorus content of the water quality were measured due to limitations in the field.

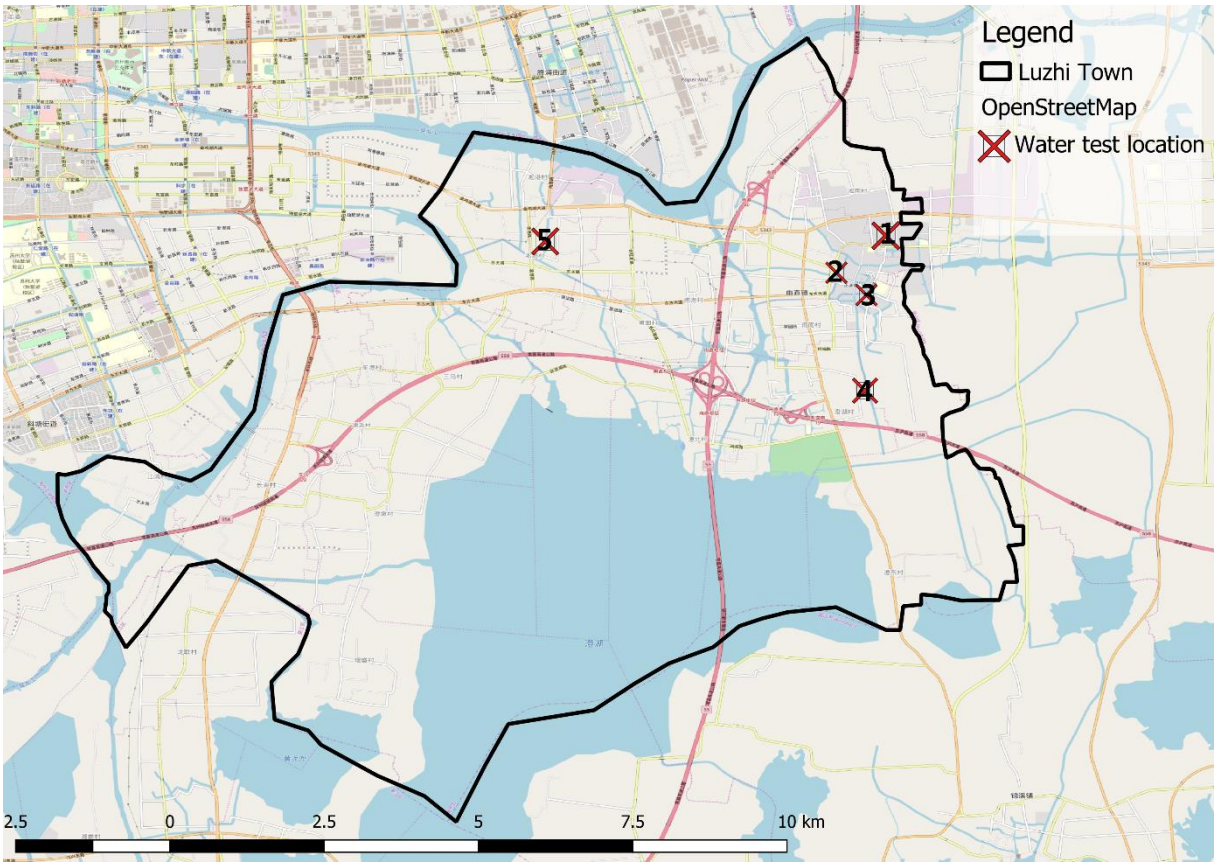


Figure 0-1 Location of water sample

The result of the water quality test is shown in Table 0-1. It makes clear that the point 2 and point 3 in tourism area achieve III-class of water quality standard, which is also the objective of water quality in the whole town. The point 4 which is located in the downstream of tourism area achieve the Ⅳ-class of water quality standard, what's more, the river goes across the residential area, so it can be considered that the river water is polluted by the residents. And point 1 and point 5 achieve the Ⅴ- class of water quality standard, which shows that the industrial area has the bad water quality and the black-smelly river still exists in point 1.

Table 0-2 The result of water quality test

Water test points	**Ammonia nitrogen (mg/L)**	**Phosphorus (mg/L)**	**Current condition (Standard)**	**Desired condition (Standard)**
1	2	2	Ⅴ- class	III-class
2	1.0	0.03	Ⅲ-class	
3	1.0	0.03	Ⅲ-class	
4	1.5	0.06	Ⅳ-class	
5	2	1	Ⅴ- class	

Details of government actions planned and to be implemented in Luzhi Village:

Management department
Beneficial department
Construction department
PAP: project affected people

Sewerage project-1

- Suzhou zhongsheng environmental restoration co. LTD
- Water affair department, Ecology and Environment Department
- Water Affairs Department, Ecology and Environment Department, Housing and urban-rural Development Department, Rural Agriculture Department, Housing and urban-rural Development Department
- Residents, farmerS

Sewerage project-2

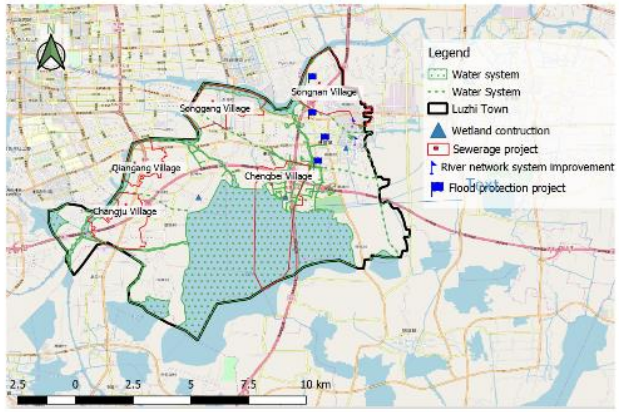
- Suzhou Wuzhong Water Development Group Co., Ltd.
- Water affair department, Ecology and Environment Department
- Water Affairs Department, Ecology and Environment Department, Development and Reform Commission, The Administrative Committee.
- Residents, Farmers, WWTP workers

Sanitation project

- Sanitation department
- Sanitation department, Water affair department, Ecology and Environment Department
- Ecology and Environment Department, Housing and urban-rural Development Department, Sanitation department, Traffic department
- sanitation workers, residents, visitors

River chief system

- The Administrative Committee, River chief office
- Water Affairs Department, Ecology and Environment Department, Development and Reform Commission, River chief office
- Water Affairs Department, Ecology and Environment Department, Development and Reform Commission, The Administrative Committee, River chief office
- Residents, leaders of government



River network system improvement

- Water affair department, Ecology and Environment Department
- Water affair department, Ecology and Environment Department, Rural Agriculture Department, Landscape and Forestry Department
- Water Affairs Department, Ecology and Environment Department, The Administrative Committee, Landscape and Forestry Department, Urban Management Department
- Residents, Shops in tourist area, industry
-

Flood protection project

- Wuzhong luzhi water conservancy service centre
- Water affair department, Ecology and Environment Department, Traffic department
- Water Affairs Department
- Ecology and Environment Department, Housing and urban-rural Development Department, Traffic Department, Finance department
- Residents live near surrounding area

Wetland construction

- Suzhou shui baxian tourism development co. LTD, Suzhou luzhi tourism development
- Water affair department, Ecology and Environment Department, Finance Department
- Water Affairs Department, Ecology and Environment Department, Housing and urban-rural Development Department, Rural Agriculture Department, Landscape and Forestry Department
- Farmers, tourists, residents

Figure 2 Stakeholders of governmental actions

Table 3 The details of sewerage project and flood protection project

Name of action	**Sewerage project**		**Flood protection project**
References	(Guan, 2015; The Housing and Urban-rural Development Department of Luzhi Town, 2019; The People's Government of Luzhi Town, 2019; The People's Government of Wuzhong District, 2017; The Planning Department of Suzhou, 2017; The Water Resource Department of Suzhou, 2019)		(Suzhou Planning and Design Research Institute, 2016; The Planning Department of Suzhou, 2017; The Water Resource Department of Suzhou, 2019)
Contents	• Using the separated system in new construction area and changing the old combined system to separated system step by step • All domestic sewage generated by rural households can be discharged to the pipe network. Firstly, dirt can be isolated through grille Wells. Then, sewage can be discharged into the main pipe by means of lifting pump station and concentrated in the waste water treatment plant for treatment (The Planning Department of Suzhou, 2017)	• Plan to dismantle the old waste water treatment plant in Luzhi village, and change it to sewage pumping station, which can upgrade the sewage from the original service area to the new construction of waste water treatment plant • The expansion construction of waste water treatment plant (The Planning Department of Suzhou, 2017)	According to the flood control standard, the levees of Luzhitang, Qingxiaogang, Tuang river, Xijiang, Xiqu pu and Tiangugang were raised and reinforced (Suzhou Planning and Design Research Institute, 2016)

Name of action	**Sewerage project**		**Flood protection project**
Place	2015: 39 natural villages (Guan, 2015) 2019: Songpu Village, Songnan Village, Songgang Village, Qiangang Village, Changju Village, Chengbei Village	The new waste water treatment plant is located in Linggang industrial park	Luzhitang, Qingxiaogang, Tuang river, Xijiang, Xiqu pu and Tiangugang
Objective	To achieve the goal which covers the domestic waste water treatment in rural area and being a part of the beautiful village project construction	Effluent water quality meets pollutant discharge standard of urban sewage treatment plant (The Water Resource Department of Suzhou, 2019) and the WWTP can cover all the waste water of the whole village	The flood control standard is once in 50 years. The elevation of the embankment is not less than 5.5 meters, and the elevation of the gate is not less than 5 meters (The Planning Department of Suzhou, 2017)
What is being done	Laying storm water pipes, sewage pipes, inspection Wells and road surface repair in rural area (The Housing and Urban-rural Development Department of Luzhi Town, 2019). In 2015, 39 natural villages already finished the separation system construction (Guan, 2015).	The new waste water treatment plant have been constructed	From 2011 to 2014, the construction of unblocked river channel was implemented. In 2012, combined semi-high land, existing polder area with the project of diverting water through the ancient town and flood control project, a total of 8 united country walls were formed in Luzhi Town by the end of 2014, covering an area of 38km2, accounting for 52% of the land area of the whole town. But 15% of the levees, about 11km long, are not up to standard (The Planning Department of Suzhou, 2017)
Time horizon	2015-2065	2011-2030	2011-2030

Name of action	Sewerage project		Flood protection project
How many people are beneficial	3410 (Guan, 2015; The People's Government of Luzhi Town, 2019)	0.22 million (The Planning Department of Suzhou, 2017)	
Cost	49.55 million RMB (or 6.4 million Euro) (Guan, 2015; The Housing and Urban-rural Development Department of Luzhi Town, 2019)	68.9 million (or 8.8 million Euro) (The People's Government of Wuzhong District, 2017)	0.44million (or 56 000 Euro)
Funding	The Finance Department of Luzhi Town (Guan, 2015)	Suzhou Wuzhong Water Development Group Co., Ltd. (The Housing and Urban-rural Development Department of Luzhi Town, 2019)	The Finance Department of Luzhi Town
Management department	Suzhou Zhongsheng environmental restoration co. LTD	Suzhou Wuzhong Water Development Group Co., Ltd (The Housing and Urban-rural Development Department of Luzhi Town, 2019)	Wuzhong Luzhi water conservancy service centre
Benefit department	The Water Affair Department of Luzhi Town, Ecology and Environment Department	The Water Affair Department of Luzhi Town, Ecology and Environment Department	The Water Affair Department of Luzhi Town, Ecology and Environment Department, Traffic department
construction department	Water Affairs Department, Ecology and Environment Department, Housing and urban-rural Development Department, Rural Agriculture Department, Housing and urban-rural Development Department (The	Water Affairs Department, Ecology and Environment Department, Development and Reform Commission, The Administrative Committee (The Water Resource Department of Suzhou, 2019)	The Water Affair Department of Luzhi Town, Ecology and Environment Department, Housing and urban-rural Development Department, Traffic Department, Finance department (The Water Resource Department of Suzhou, 2019)

Name of action	Sewerage project		Flood protection project
	Water Resource Department of Suzhou, 2019)		
PAP: project affected people	Residents, farmers	Residents, farmers, workers of waste water treatment plant	Residents live near surrounding area

Table 4 The details of sanitation project and river chief system

Name of action	Sanitation project		River chief system
References	(Suzhou Planning and Design Research Institute, 2016; The Planning Department of Suzhou, 2017; The Water Resource Department of Suzhou, 2019)		(The People's Government of Luzhi Town, 2018; The Planning Department of Suzhou, 2017; The State Council of China, 2016; The Water Affairs Department of Suzhou, 2020; The Water Resource Department of Suzhou, 2019)
Contents	Construct public toilet near crowd gathering place (Suzhou Planning and Design Research Institute, 2016)	Set up refuse/garbage collection station in residents' area and send to Suzhou city garbage treatment plant (Suzhou Planning and Design Research Institute, 2016)	The principals of the party and government at all levels in China serve as the "river chiefs" and are responsible for organizing and leading the management and protection of the corresponding rivers and lakes (The State Council of China, 2016)
Place	In the tourism area	In residential area	367 rivers/canals/lakes (The People's Government of Luzhi Town, 2018)
Objective	The Luzhi environmental health station after reform is responsible for all the public toilet, the number of sanitation workers shall be provided according to the 2 ~ 2.5‰	The treatment of domestic garbage in luzhi village is sent to suzhou municipal garbage treatment plant for unified treatment (The	Ensure that the treatment rate reaches 90 percent, eliminate the black smelly water and bad Ⅴ class water by the end of 2020 (The Water Affairs Department of Suzhou, 2020)

Name of action	Sanitation project		River chief system
	of urban population(⩾ 350) (The Planning Department of Suzhou, 2017)	Planning Department of Suzhou, 2017)	
What is being done	The Compression Station of Luzhi Township Sanitation Station on Dongsheng Road covers an area of 0.33 hectares and has a processing capacity of 180 tons / day. There are currently 160 public toilets in the town (The Planning Department of Suzhou, 2017)	Three small refuse transfer stations are set up in luzhi central village, new village and office respectively (The Planning Department of Suzhou, 2017)	237 river chiefs cover 367 rivers (The People's Government of Luzhi Town, 2018)
Time horizon	2011-2030		From 2016 onwards
How many people are beneficial	0.22 million (The Planning Department of Suzhou, 2017)		0.22 million (The Planning Department of Suzhou, 2017)
Cost			
Funding	The Finance Department of Luzhi Town		
Management department	The Sanitation Department of Luzhi Town		The Administrative Committee, River chief office
Benefit department	Sanitation department, The Water Affair Department of Luzhi Town, Ecology and Environment Department	Sanitation department, Ecology and Environment Department	Water Affairs Department, Ecology and Environment Department, Development and Reform Commission, River chief office
Construction department	Ecology and Environment Department, Housing and urban-rural Development Department,	Ecology and Environment Department, Housing and urban-rural Development Department,	Water Affairs Department, Ecology and Environment Department, Development and Reform Commission, The Administrative

Name of action	Sanitation project		River chief system
	Sanitation department, Traffic department (The Water Resource Department of Suzhou, 2019)	Sanitation department (The Water Resource Department of Suzhou, 2019)	Committee, River chief office (The Water Resource Department of Suzhou, 2019)
PAP	sanitation workers, residents, visitors		Residents, leaders of government

Table 5 The details of river network system improvement and wetland construction

Name of action	River network system improvement		Wetland construction
References	(Lu, 2019; The Ecology and Environment Department of Jiangsu Province, 2019; The Water Resource Department of Suzhou, 2019)		(Suzhou Luzhi Tourism Development co. LTD, 2011; Suzhou Shui Baxian Tourism Development co. LTD, 2016; The Water Resource Department of Suzhou, 2019; Xu et al., 2010)
Contents	Improve the river system layout	Clean the black-smelly canals, control the pollutant source (The Ecology and Environment Department of Jiangsu Province, 2019)	• Shui Ba xian ecological cultrural wetland park construction • Songnan Ecological Agricultural area (Suzhou Luzhi Tourism Development co. LTD, 2011) • An artificial wetland near xihui River in tourism area (Xu et al., 2010)
Place	Central river management project (Lu, 2019)	Black-smelly river improvement: Sianbang (The Ecology and Environment Department of Jiangsu Province, 2019)	Shuibaxian: Located on the shore of Cheng Lake Lake in the southeast of Suzhou city, and near to the Suzhou industrial park; Songnan Village; Artificial wetland: near Xihui River

Name of action	River network system improvement		Wetland construction
Objective	Increase the hydrodynamics to improve the self-cleaning of water body (Lu, 2019)	By the end of 2020, black and smelly water bodies in urban and rural areas can be basically eliminated (The Water Resource Department of Suzhou, 2019)	By the end of 2020, black and smelly water bodies in urban and rural areas can be basically eliminated (The Water Resource Department of Suzhou, 2019)
What is being done	Add 1 river to optimize the water system structure, connect 5 water blocking nodes, 4 pump gates are used for joint dispatch and hydrodynamic control (Lu, 2019)	After cleaning, at present, there are 1 district-level black odorous water body, 6 suspected black odorous water bodies, and 49 inferior V-class rivers (The Ecology and Environment Department of Jiangsu Province, 2019)	Shui Ba xian ecological cultrural wetland park, Songnan Ecological Agricultural area, An artificial wetland near xihui River in tourism area have been constructed
Time horizon		2011-2020 (The Ecology and Environment Department of Jiangsu Province, 2019)	2011-2030
How many people are beneficial			0.22 million
Cost			150million (or 19 million Euro) (Suzhou Luzhi Tourism Development co. LTD, 2011; Suzhou Shui Baxian Tourism Development co. LTD, 2016)
Funding	The Finance Department of Luzhi Town	The Finance Department of Luzhi Town	Suzhou shui baxian tourism development co. LTD; Suzhou luzhi tourism development (Suzhou Luzhi Tourism Development co. LTD, 2011)
Management department	The Water Affair Department of Luzhi Town; The Ecology and	The Ecology and Environment Department of Luzhi Town	Suzhou Shui Baxian Tourism Development co. LTD; Suzhou Luzhi Tourism Development co. LTD (Suzhou

Name of action	River network system improvement		Wetland construction
	Environment Department of Luzhi Town		Luzhi Tourism Development co. LTD, 2011)
Benefit department	The Water Affair Department of Luzhi Town; The Ecology and Environment Department of Luzhi Town	The Water Affair Department of Luzhi Town, Ecology and Environment Department, Rural Agriculture Department, Landscape and Forestry Department	The Water Affair Department of Luzhi Town, Ecology and Environment Department, Finance Department
Construction department	The Water Affair Department of Luzhi Town; The Ecology and Environment Department of Luzhi Town; The Urban Management Department of Luzhi Town; The Traffic Department of Luzhi Town (The Water Resource Department of Suzhou, 2019)	Water Affairs Department, Ecology and Environment Department, The Administrative Committee, Landscape and Forestry Department, Urban Management Department (The Water Resource Department of Suzhou, 2019)	Water Affairs Department, Ecology and Environment Department, Housing and urban-rural Development Department, Rural Agriculture Department, Landscape and Forestry Department (The Water Resource Department of Suzhou, 2019)
PAP	Residents in tourism area, Shops in tourist area	Residents near Sianbang River, industry workers	Farmers, tourists, residents

SWOT analysis:

SWOT analysis represents strength, weakness, opportunity and threat. Strength and weakness are the internal properties of the projects, and the opportunity and threat are the external properties of the projects, which is mainly about the impact of the external environment. Based on the details of these actions, the SWOT analysis can help to understand the governmental actions better for the stakeholders so that the stakeholders can try to improve the projects, which can strengthen the positive impact and escape the possible consequence.

Table 6 SWOT analysis of river chief system

Strength	**Opportunity**
• It can build detailed archives for each river, and carried out targeted source control and anti-pollution (Liu et al., 2019) • The accountability system makes the river chief focus on the water environment problems, and find the balance between economic growth and pollutant control • Improve the water quality (Liu et al., 2019)	• Strengthen the cooperation of each department: because of the complexity and diversity of water pollutant source, each department should cooperate together to control the pollutant. RCS can offer the flat for information communication (China Daily, 2016) • The work of water ecological environment management is included in the performance appraisal of the river chief, and the responsibilities and tasks of the river chief are clarified. They are urged to face up to the problem and solve it, which effectively increased the government's input in ecological and water environment management, and improve the status of water pollution control in decision-making (Liu et al., 2019) • Increased the enthusiasm of the masses for participation
Weakness	**Threat**
• The ability and skills of river chief plays an important role in river pollutant control (C. Li et al., 2015), hence those rivers with different conditions can face different treatment efficiency • In the evaluation system of river chief, the water quality is the only parameter, which may makes the river chief not think the sustainable improvement for rivers.(Liu et al., 2019)	• When staffs of local governments change, their responsibility to river water can be affected (Liu et al., 2019)

Table 7 SWOT analysis of sewerage project

Strength	**Opportunity**

• Treat sewage water separately • Save energy: the separation system can make use of the WWTP and increase the treatment efficiency • After the separation system construction, the WWTP only need to treat the sewer water, so the scale of WWTP can be reduced	• Improve the water quality • The land use type can be changed(after the old WWTP dismantle) • Good for the storm water project. It can drain the rain water at the shortest distance • Reuse water. Some water in storm water pipe can be used in other places such as industry • Good for the sponge city construction
Weakness • High construction cost(separation system and WWTP construction) • It is hard to stop people to connect pipe without permission • The wrong pipe connection happens due to construction/design error and unpermitted private pipe connection • The old area has the complex and old pipe system, which makes the separation system hard to build	**Threat** • The construction period can have negative impact on residents life • The untreated storm water might affect the water quality of down stream • The separation system is not suitable for all places

Table 7 SWOT analysis of flood protection project

Strength • Making use of existing facilities, easy to manage • low cost	**Opportunity** • Change the land use type • Detention and flood storage
Weakness • Conditions of existing facilities such as dams and dikes are not known, which may have weak flood protection	**Threat** • Cannot cover all the village area, so it can bring some threat to the unprotected area • Have some negative impact for detention basin

Table 8 SWOT analysis of sanitation project

Strength • The more garbage bins are set in residential areas, which can avoid the overflowing trash • It can improve the health habit of residents to let people throw the garbage into bins instead of put it at the street corner	**Opportunity** • Clean the village environment • Improve the village infrastructure • Save energy • Improve water quality

Weakness	Threat
• It also require high cost and time to invest • Some residential areas don't have enough public space to put the garbage bins	• On the way to the Suzhou garbage treatment plan, the garbage may be left on the road • The uncivilized behaviour leads the hard management

For the wetland construction, the SWOT analysis is shown as Table 9.Table 9 SWOT analysis of wetland construction

Strength	Opportunity
• It's cheap to build and run • It is easy to maintain, as it has low mechanical components	• Improve the water quality • Social function • Protect the biodiversity • Microclimate control • Detention/flood storage • Offer some economic value, such as aquatic products, livestock, building materials, greening • Increase the public participation • Good for sponge city construction
Weakness	**Threat**
• Not stable, it is easy to face the insects damage • It's heavily influenced by climate • Large land requirement	• In the future it may cause limit to economic use as the land is expensive

Table 10 SWOT analysis of river network system improvement

Strength	Opportunity
• Control the pollutant source makes the river cannot be polluted • Eliminate the inner pollutant source: original sludge	• Improve the water quality • Increase the water discharge, which can strength the river self-purification ability • Good for sponge city construction • Increase the public participation • Flood storage/ detention
Weakness	**Threat**
• The layout design is based on the model simulation, which has some differences from the real rivers • The added rivers can add the possibility of water pollutant	• The change of river layout can lead to displacement of somebody's place • The water blocking nodes is usually connected by pipe, which also need pump. It can waste energy

Ascertaining the DPSIR elements in the water quality context in Luzhi village

To make the DPSIR on water quality impact on the Luzhi village system it is important to frame the government actions at the response, and the current status at the state, then the driver, pressure and impacts.

Table 11 DPSIR framework of sewerage project

Driver	Economic level, public awareness	Technology, Economic level	Technology, land requirement, pipe system, the ratio of domestic sewage and industrial sewage
Pressure	The rural residents don't have enough money and awareness to change the pipe system themselves	• Expensive separation system construction • The complex pipe system in old area	Combined system makes the WWTP hard to treat water in raining days The limited
State	The rural sewerage system doesn't cover all the villages	Some old area still use the combined system	The old WWTP cannot treat all the current waste water, the effluent water quality is unstable and there is a risk of excessive discharge
Impact	The river water in villages is affected by domestic waste water	In raining days, the overflow can affect the water quality, and cause the urban flood	The overflow water can affect the water quality in rivers in raining days
Response	Construct the rural sewerage system	Change the current combined system to separation system	Change the old WWTP to a sewerage pump station, and construct a new one

Table 12 DPSIR framework of flood protection project

Driver	Climate change
Pressure	Heavy rain
State	The current flood protection and waterlogging drainage project is not suitable for the current drainage requirement
Impact	The whole town face the flood risk
Response	Flood protection project

Table 13 DPSIR framework of sanitation project

Driver	Tourism, population, urbanization

Pressure	Tourism development, increasing population
State	• The increasing tourists and residents need more public infrastructure • The disposal capacity of domestic garbage cannot keep pace with the development of production • Garbage littering phenomenon exists in rural area
Impact	The environment is polluted
Response	• Set up the public toilets • Set up the garbage collection station

Table 14 DPSIR framework of river chief system

Driver	Economy, urbanisation, land use,
Pressure	Development of economy
State	Some new problems have appeared in the management and protection of rivers and lakes in China
Impact	The water environment protection is lack of the
Response	River chief system

Table 15 DPSIR framework of river network system improvement

Driver	Hydraulics(Changes to river section)	Economic dependence, land use
Pressure	Drainage congestion	Industry waste, agriculture pollutant
State	The current water system layout makes the river discharge low	There is still some black-smelly rivers exist
Impact	The low discharge cause low self-clean ability	Affect the downstream of water quality and residents' life
Response	Change the river network layout	River clean

Table 16 DPSIR framework of wetland construction

Driver	Economic dependence, land use, climate change
Pressure	Industry waste, agriculture pollutant, storm water pollutant
State	The downstream of drainage channels has pollutants
Impact	The water environment is affected
Response	Wetland construction

Annex B. SWOT analysis of governmental actions in future scenarios

Scenario Ⅰ

For River chief system:

S • Improve the water quality • Build detailed archive for each river, which can carry out targeted source control and anti-pollution • It's easier for river chief to balance the economic development and environmental protection • It is easier for river chief to control the pollutant source • Strengthen the awareness of river chief to improve the water quality to remain the good environment	**O** • Strengthen the cooperation of each department: because of the complexity and diversity of water pollutant source, each department should cooperate together to control the pollutant. RCS can offer the flat for information communication. • The work of water ecological environment management is included in the performance appraisal of the river chief, and the responsibilities and tasks of the river chief are clarified. They are urged to face up to the problem and solve it, which effectively increased the government's input in ecological and water environment management, and improve the status of water pollution control in decision-making. • Increased the enthusiasm of the masses for participation
W • The ability and skills of river chief plays an important role in river pollutant control, hence those rivers with different conditions can face different treatment efficiency • In the evaluation system of river chief, the water quality is the only parameter, which may makes the river chief not think the sustainable improvement for rivers. • It is hard to control the tourists' behaviour, which increase the difficulty of river chief's work	**T** • When staffs of local governments change, their responsibility to river water can be affected.(Liu et al., 2019)

For Sewerage project:

S	**O**
• Treat sewage water separately • Save energy: the separation system can make use of the WWTP and increase the treatment efficiency • After the separation system construction, the WWTP only need to treat the sewer water, so the scale of WWTP can be reduced • The storm water can be discharged to green land firstly to reduce the pollution of downstream • The ratio of domestic waste water is increasing, which has simpler and less expensive process	• Improve the water quality • The land use type can be changed(after the old WWTP dismantle) • Good for the storm water project. It can drain the rain water at the shortest distance • Reuse water. Some water in storm water pipe can be used in other places such as industry • Good for the sponge city construction • Green land area can delay the storm water into pipe • Green land can reduce the damage of unpermitted private pipe connection
W	**T**
• High construction cost(separation system and WWTP construction) • The wrong pipe connection happens due to construction/design error and unpermitted private pipe connection • The old area(tourism area) has the complex and old pipe system, which makes the separation system hard to build • Waste energy: The increasing tourism development lead increasing domestic water use, which can change the emphasis of WWTP. So the WWTP can add more facilities on domestic waste water treatment, and throw away the old industry waste water treatment facilities.	• The construction period can have negative impact on residents life • The separation system is not suitable for all places

For flood protection project:

S	**O**
• Making use of existing facilities, easy to manage • low cost • Have more green land area for detention basin • Green land area can delay the storm water	• Change the land use type • Detention and flood storage
W	**T**
• Conditions of existing facilities such as dams and dikes are not known, which may have weak flood protection	• Cannot cover all the village area, so it can bring some threat to the unprotected area • Have some negative impact for detention basin

For sanitation project:

S	**O**
• The more garbage bins are set in residential areas, which can avoid the overflowing trash • It can improve the health habit of residents to let people throw the garbage into bins instead of put it at the street corner	• Clean the village environment • Improve the village infrastructure • Save energy • Improve water quality • Complete public sanitation facilities meet the requirement of tourism development, which also improve the tourists' experience
W	**T**
• It also require high cost and time to invest. • Some residential areas don't have enough public space to put the garbage bins.	• On the way to the Suzhou garbage treatment plan, the garbage may be left on the road • The uncivilized behaviour leads the hard management • In rural area, some people may accumulate the garbage in green land

For wetland construction:

S	**O**
• It's cheap to build and run • It is easy to maintain, as it has low mechanical components • Have more green land area to construct wetland	• Improve the water quality • Social function • Protect the biodiversity • Microclimate control • Detention/flood storage • Offer some economic value, such as aquatic products, livestock, building materials, greening • Increase the public participation • Good for sponge city construction • Good for tourism development
W	**T**
• Not stable, it is easy to face the insects damage • It's heavily influenced by climate	• In the future it may cause limit to economic use as the land is expensive

For river network system improvement:

S	**O**
• Control the pollutant source makes the river cannot be polluted • Eliminate the inner pollutant source: original sludge	• Improve the water quality • Increase the water discharge, which can strength the river self-purification ability • Good for sponge city construction • Increase the public participation • Flood storage/ detention • River clean is good for tourism development
W	**T**
• The layout design is based on the model simulation, which has some differences from the real rivers • The added rivers can add the possibility of water pollutant	• The change of river layout can lead to displacement of somebody's place • The water blocking nodes is usually connected by pipe, which also need pump. It can waste energy

Scenario II

For river chief system:

S	**O**

• It can build detailed archives for each river, and carried out targeted source control and anti-pollution. • The accountability system makes the river chief focus on the water environment problems, and find the balance between economic growth and pollutant control • Improve the water quality • It's easier for river chief to balance the economic development and environmental protection • It is easier for river chief to control the pollutant source • Strengthen the awareness of river chief to improve the water quality to remain the good environment	• Strengthen the cooperation of each department: because of the complexity and diversity of water pollutant source, each department should cooperate together to control the pollutant. RCS can offer the flat for information communication. • The work of water ecological environment management is included in the performance appraisal of the river chief, and the responsibilities and tasks of the river chief are clarified. They are urged to face up to the problem and solve it, which effectively increased the government's input in ecological and water environment management, and improve the status of water pollution control in decision-making. • Increased the enthusiasm of the masses for participation
W • The ability and skills of river chief plays an important role in river pollutant control, hence those rivers with different conditions can face different treatment efficiency • In the evaluation system of river chief, the water quality is the only parameter, which may makes the river chief not think the sustainable improvement for rivers. • It is hard to control the tourists' behaviour, which increase the difficulty of river chief's work • The small green land area limit the river chief to improve water quality	**T** • When staffs of local governments change, their responsibility to river water can be affected.

For sewerage project:

S	**O**
• Treat sewage water separately • Save energy: the separation system can make use of the WWTP and increase the treatment efficiency • After the separation system construction, the WWTP only need to treat the sewer water, so the scale of WWTP can be reduced • The ratio of domestic waste water is increasing, which has simpler and less expensive process	• Improve the water quality • The land use type can be changed(after the old WWTP dismantle) • Good for the storm water project. It can drain the rain water at the shortest distance • Reuse water. Some water in storm water pipe can be used in other places such as industry • Good for the sponge city construction
W	**T**
• High construction cost(separation system and WWTP construction) • It is hard to stop people to connect pipe without permission • The wrong pipe connection happens due to construction/design error and unpermitted private pipe connection • The old area has the complex and old pipe system, which makes the separation system hard to build • Waste energy: The increasing tourism development lead increasing domestic water use, which can change the emphasis of WWTP. So the WWTP can add more facilities on domestic waste water treatment, and throw away the old industry waste water treatment facilities.	• The construction period can have negative impact on residents life • The untreated storm water might affect the water quality of down stream • The separation system is not suitable for all places

For flood protection project:

S • Making use of existing facilities, easy to manage • low cost	**O** • Change the land use type • Detention and flood storage
W • Conditions of existing facilities such as dams and dikes are not known, which may have weak flood protection • Have less green area to be detention basin	**T** • Cannot cover all the village area, so it can bring some threat to the unprotected area • The water conservancy facilities construction may affect the biotic environment with small green land • The water conservancy facilities may cause the decrease of water level of downstream, which is in the tourism area

For sanitation project:

S • The more garbage bins are set in residential areas, which can avoid the overflowing trash • It can improve the health habit of residents to let people throw the garbage into bins instead of put it at the street corner • Complete public sanitation facilities meet the requirement of tourism development, which also improve the tourists' experience	**O** • Clean the village environment • Improve the village infrastructure • Save energy • Improve water quality
W • It also require high cost and time to invest. • Some residential areas don't have enough public space to put the garbage bins.	**T** • On the way to the Suzhou garbage treatment plan, the garbage may be left on the road • The uncivilized behaviour leads the hard management

For wetland construction:

S	**O**
• It's cheap to build and run • It is easy to maintain, as it has low mechanical components	• Improve the water quality • Social function • Protect the biodiversity • Microclimate control • Detention/flood storage • Offer some economic value, such as aquatic products, livestock, building materials, greening • Increase the public participation • Good for sponge city construction • Good for tourism development
W	**T**
• Not stable, it is easy to face the insects damage • It's heavily influenced by climate • Large land requirement • Have less green land to construct the wetland	• In the future it may cause limit to economic use as the land is expensive

For river network system improvement:

S	**O**
• Control the pollutant source makes the river cannot be polluted • Eliminate the inner pollutant source: original sludge	• Improve the water quality • Increase the water discharge, which can strength the river self-purification ability • Good for sponge city construction • Increase the public participation • Flood storage/ detention • Good for tourism development
W	**T**
• The layout design is based on the model simulation, which has some differences from the real rivers • The added rivers can add the possibility of water pollutant	• The change of river layout can lead to displacement of somebody's place

• The lack of green area makes the river clean not sustainable	• The water blocking nodes is usually connected by pipe, which also need pump. It can waste energy

Scenario III

For river chief system:

S • It can build detailed archives for each river, and carried out targeted source control and anti-pollution. • The accountability system makes the river chief focus on the water environment problems, and find the balance between economic growth and pollutant control • Improve the water quality • Push the river chief to change the current industry into low-pollution industry	**O** • Strengthen the cooperation of each department: because of the complexity and diversity of water pollutant source, each department should cooperate together to control the pollutant. RCS can offer the flat for information communication. • The work of water ecological environment management is included in the performance appraisal of the river chief, and the responsibilities and tasks of the river chief are clarified. They are urged to face up to the problem and solve it, which effectively increased the government's input in ecological and water environment management, and improve the status of water pollution control in decision-making. • Increased the enthusiasm of the masses for participation
W • The ability and skills of river chief plays an important role in river pollutant control, hence those rivers with different conditions can face different treatment efficiency • In the evaluation system of river chief, the water quality is the only parameter, which may makes the river chief not think the sustainable improvement for rivers. • The small green land area limit the river chief to improve water quality • It's hard for river chief to balance the economic development and environmental protection	**T** • When staffs of local governments change, their responsibility to river water can be affected.

For sewerage project:

S	**O**
• Treat sewage water separately • Save energy: the separation system can make use of the WWTP and increase the treatment efficiency • After the separation system construction, the WWTP only need to treat the sewer water, so the scale of WWTP can be reduced	• Improve the water quality • The land use type can be changed(after the old WWTP dismantle) • Good for the storm water project. It can drain the rain water at the shortest distance • Reuse water. Some water in storm water pipe can be used in other places such as industry • Good for the sponge city construction
W	**T**
• High construction cost(separation system and WWTP construction) • It is hard to stop people to connect pipe without permission • The wrong pipe connection happens due to construction/design error and unpermitted private pipe connection • The old area has the complex and old pipe system, which makes the separation system hard to build • WWTP need to improve the treatment process to reduce the damage of industry waste water	• The construction period can have negative impact on residents life • The separation system is not suitable for all places • The untreated storm water might affect the water quality of down stream • The unpermitted private pipe connection of industry can cause high pollution in river

For flood protection project:

S	**O**
• Making use of existing facilities, easy to manage • low cost	• Change the land use type • Detention and flood storage
W	**T**
• Conditions of existing facilities such as dams and dikes are not known, which may have weak flood protection • Have less green area to be detention basin	• Cannot cover all the village area, so it can bring some threat to the unprotected area • The water conservancy facilities construction may affect the biotic environment with small green land

For sanitation project:

S	**O**
• The more garbage bins are set in residential areas, which can avoid the overflowing trash • It can improve the health habit of residents to let people throw the garbage into bins instead of put it at the street corner	• Clean the village environment • Improve the village infrastructure • Save energy • Improve water quality
W	**T**
• It also require high cost and time to invest. • Some residential areas don't have enough public space to put the garbage bins.	• On the way to the Suzhou garbage treatment plan, the garbage may be left on the road • The uncivilized behaviour leads the hard management

For wetland construction:

S	**O**
• It's cheap to build and run • It is easy to maintain, as it has low mechanical components • Protect the surrounding environment of industrial park	• Improve the water quality • Social function • Protect the biodiversity • Microclimate control • Detention/flood storage • Offer some economic value, such as aquatic products, livestock, building materials, greening • Increase the public participation • Good for sponge city construction
W	**T**
• Not stable, it is easy to face the insects damage • It's heavily influenced by climate • Have less green land to construct the wetland	• In the future it may cause limit to economic use as the land is expensive

River network system improvement

S • Control the pollutant source makes the river cannot be polluted • Eliminate the inner pollutant source: original sludge	**O** • Improve the water quality • Increase the water discharge, which can strength the river self-purification ability • Good for sponge city construction • Increase the public participation • Flood storage/ detention
W • The layout design is based on the model simulation, which has some differences from the real rivers • The added rivers can add the possibility of water pollutant • The lack of green area makes the river clean not sustainable • River cleaning is not a sustainable measure under the industry development condition	**T** • The change of river layout can lead to displacement of somebody's place • Waste energy: The water blocking nodes is usually connected by pipe, which also need pump.

Scenario Ⅳ

For river chief system:

S • It can build detailed archives for each river, and carried out targeted source control and anti-pollution. • The accountability system makes the river chief focus on the water environment problems, and find the balance between economic growth and pollutant control • Improve the water quality • Push the river chief to change the current industry into low-pollution industry	**O** • Strengthen the cooperation of each department: because of the complexity and diversity of water pollutant source, each department should cooperate together to control the pollutant. RCS can offer the flat for information communication. • The work of water ecological environment management is included in the performance appraisal of the river chief, and the responsibilities and tasks of the river chief are clarified. They are urged to face up to the problem and solve it, which effectively increased the government's input in ecological and water environment management, and improve the status of water pollution control in decision-making. • Increased the enthusiasm of the masses for participation
W • The ability and skills of river chief plays an important role in river pollutant control, hence those rivers with different conditions can face different treatment efficiency • In the evaluation system of river chief, the water quality is the only parameter, which may makes the river chief not think the sustainable improvement for rivers. • It's hard for river chief to balance the economic development and environmental protection	**T** • When staffs of local governments change, their responsibility to river water can be affected.

For sewerage project:

S	**O**
• Treat sewage water separately • Save energy: the separation system can make use of the WWTP and increase the treatment efficiency • After the separation system construction, the WWTP only need to treat the sewer water, so the scale of WWTP can be reduced • The storm water can be discharged to green land firstly to reduce the pollution of downstream	• Improve the water quality • The land use type can be changed(after the old WWTP dismantle) • Good for the storm water project. It can drain the rain water at the shortest distance • Reuse water. Some water in storm water pipe can be used in other places such as industry • Good for the sponge city construction • Green land area can delay the storm water into pipe • Green land can reduce the damage of unpermitted private pipe connection
W	**T**
• High construction cost(separation system and WWTP construction) • It is hard to stop people to connect pipe without permission • The wrong pipe connection happens due to construction/design error and unpermitted private pipe connection • The old area has the complex and old pipe system, which makes the separation system hard to build • WWTP need to improve the treatment process to reduce the damage of industry waste water	• The construction period can have negative impact on residents life • The separation system is not suitable for all places • The unpermitted private pipe connection of industry can cause high pollution in river

For flood protection project:

S	**O**
• Making use of existing facilities, easy to manage • low cost • Have more green land area for detention basin • Green land area can delay the storm water	• Change the land use type • Detention and flood storage
W	**T**
• Conditions of existing facilities such as dams and dikes are not known, which may have weak flood protection	• Cannot cover all the village area, so it can bring some threat to the unprotected area

For sanitation project:

S	**O**
• The more garbage bins are set in residential areas, which can avoid the overflowing trash • It can improve the health habit of residents to let people throw the garbage into bins instead of put it at the street corner	• Clean the village environment • Improve the village infrastructure • Save energy • Improve water quality
W	**T**
• It also require high cost and time to invest • Some residential areas don't have enough public space to put the garbage bins	• On the way to the Suzhou garbage treatment plan, the garbage may be left on the road • The uncivilized behaviour leads the hard management • In rural area, some people may accumulate the garbage in green land

For wetland construction:

S	**O**
• It's cheap to build and run • It is easy to maintain, as it has low mechanical components • Have more green land area to construct wetland • Protect the surrounding environment of industrial park	• Improve the water quality • Social function • Protect the biodiversity • Microclimate control • Detention/flood storage • Offer some economic value, such as aquatic products, livestock, building materials, greening • Increase the public participation • Good for sponge city construction
W	**T**
• Not stable, it is easy to face the insects damage • It's heavily influenced by climate	• In the future it may cause limit to economic use as the land is expensive

For river network system improvement:

S	**O**
• Control the pollutant source makes the river cannot be polluted • Eliminate the inner pollutant source: original sludge	• Improve the water quality • Increase the water discharge, which can strength the river self-purification ability • Good for sponge city construction • Increase the public participation • Flood storage/ detention
W	**T**
• The layout design is based on the model simulation, which has some differences from the real rivers • The added rivers can add the possibility of water pollutant • River cleaning is not a sustainable measure under the industry development condition	• The change of river layout can lead to displacement of somebody's place • Waste energy: The water blocking nodes is usually connected by pipe, which also need pump.

Annex C. Impact scores based on DPSIR analysis of governmental actions in base and future scenarios

Base scenario

1. Flood protection project
    a. Sewerage project:

Pressure	The flood risk decrease
State	Surface water level decrease
Impact	There is no overflow of sewer pipe, which cannot cause damage to the road and affect the water quality
Score	1: If there is no flood protection project, the overflow only exists in extreme events. The construction of flood protection project can bring positive impact to the sewerage project, and improve the water quality finally

    b. Sanitation project:

Pressure	The flood risk decrease
State	The sanitation facilities cannot suffer from the flood
Impact	The sanitation facilities remain the same
Score	0: The change of the pressure has no impact to the sanitation project, as well as the water quality

    c. River chief system:

Pressure	Decrease the flood risk
State	The river chief doesn't have to face the water quality deterioration caused by flood
Impact	The river chief has less stress
Score	1: The river water can be improved and the river chief has less stress. But the water quality is not improved directly, so the impact to river chief is not strong

    d. River network system improvement:

Pressure	The flood risk decrease
State	The land sediments cannot move to river and the river sludge cannot increase
Impact	The water quality can be improved
Score	2: The construction of flood protection bring the very positive impact to the river network system improvement, and the water quality is improved at all times

    e. Wetland construction:

Pressure	The flood risk decrease
State	The wetland cannot be used to store water and delay surface water, and can be used for other function such as clean the river water
Impact	The river water can be cleaned
Score	1: The construction of flood protection brings positive impact to wetland, and the water quality improvement only act when the wetland is used to clean water

2. Sewerage project
    a. Flood protection project

Pressure	The dry weather flow can be discharged to WWTP steadily
State	The dry weather flow cannot be a part of flood
Impact	The water quality cannot be disturbed by flood
Score	2: The sewerage project brings very positive impact to flood protection protect due to the water quality is improved at all times

    b. Sanitation project:

Pressure	Change the sewerage system to public toilet from combined system to separation system
State	The sewage of public toilet can be discharged to WWTP
Impact	The water quality cannot be disturbed by sewage
Score	2: The construction of sewerage project brings very positive impact to sanitation project by reducing the possibility of sewage overflow to improve the water quality at all times

    c. River chief system:

Pressure	Eliminated the risk of overflow of sewer
State	The river chief doesn’t have to face the water quality deterioration caused by overflow of sewer
Impact	The river chief has less stress
Score	2: The river water can be improved and the river chief has less stress. And the water quality is improved directly, so the impact to river chief is very strong

    d. River network system improvement:

Pressure	Eliminated the risk of overflow of sewer
State	The river cannot affected by waste water and
Impact	The difficulty of clearing the river cannot increase so the river water keeps clean

Score	2: The sewerage project brings very positive impact to river network system improvement, because it cannot discharge the sewer to the river at all times, the river water cannot be affected

e. Wetland construction:

Pressure	Increase the storm water quantity
State	The wetland need to treat more storm water
Impact	The life period of wetland can be reduced, which can reduce the water quality
Score	-1: The construction of sewerage project brings negative impact to the wetland by reducing the life period, and the damage to wetlands can eventually affect water quality after a while

3. Sanitation project

a. Flood protection project

Pressure	Reduce the amount of garbage floating on the river
State	The river for flood storage is clean and no increasing river sludge
Impact	The river water is improved
Score	2: The sanitation project brings very positive impact to the flood protection project by reducing the river sludge, which can improve the river quality at last at all times

b. Sewerage project

Pressure	Increase the amount of waste water
State	The WWTP is busy
Impact	The river water may be pollutant by outflow of WWTP
Score	-1: The sanitation project brings negative impact to sewerage project, but the outflow of WWTP which cannot achieve the standard only occurs in large amount of waste water treatment

c. River chief system:

Pressure	Reduce the garbage on the river
State	The river chief doesn’t have to face the water quality deterioration caused by garbage
Impact	The river chief has less stress
Score	1: The river water can be improved and the river chief has less stress. And the water quality is not improved directly, sometimes the garbage may still exists by uncivilized behaviour. So the impact to river chief is not very strong

d. River network system improvement:

Pressure	Decrease the garbage on the river
State	The river surface is clean
Impact	The river sludge cannot increase
Score	2: The sanitation project brings positive impact to river network system improvement by decreasing the garbage to reduce the river sludge, then the difficulty of river cleaning can also be reduced. Although the uncivilized behaviour still let the tourists throw the garbage into the river, can be scenic staff to salvage floating objects from the river, which means the water quality can be improved at all times

e. Wetland construction:

Pressure	Reducing the garbage dump on wetland
State	The wetland works as normal
Impact	The wetland can be used to clean water to improve the water quality
Score	2: The sanitation project brings very positive impact to wetland construction by reducing the possibility of wetland damage

4.

5. River chief system
    a. Flood protection project

Pressure	Speed up construction
State	Flood protection project can be completed in advance
Impact	The flood project can be used in advance
Score	1: River chief system brings positive impact to flood protection project. The flood construction cannot improve the water quality directly, so only some river chief can push to construct the flood protection project. So the water quality can be improved, but it depend on the river chief

    a. Sewerage project

Pressure	Speed up construction
State	Sewerage project can be completed in advance
Impact	The sewerage project can be used in advance, so the water quality can be improved
Score	2: River chief system brings very positive impact to sewerage project by constructing the project in advance, which means the water can be improved easier. In addition, the sewerage project can improve the water quality directly, so the river chief is caning to construct it

    b. Sanitation project:

Pressure	Speed up construction
State	Sanitation project can be completed in advance
Impact	The sanitation project can be used in advance
Score	1: River chief system brings positive impact to sanitation project by constructing the project in advance, which means the water can be improved easier. But the sanitation project doesn’t improve the water quality directly, so maybe the river chief won't give it priority

    c. River network system improvement:

Pressure	Speed up construction
State	River network system improvement can be completed in advance
Impact	The river can has higher discharge and be cleaner in advance
Score	2: River chief system brings very positive impact to river network system improvement by constructing the project in advance, which means the water can be improved easier. In addition, river network system improvement can improve the water quality directly, so the river chief is caning to construct it

    d. Wetland construction:

Pressure	Speed up construction

State	Wetland construction can be completed in advance
Impact	Wetland can be used in advance
Score	2: River chief system brings very positive impact to wetland construction by constructing the project in advance, which means the water can be improved easier. In addition Wetland construction can improve the water quality directly, so the river chief is caning to construct it

6. River network system improvement
    a. Flood protection project

Pressure	Layout changing decrease the flood risk
State	Some flood cannot happen
Impact	The increasing river discharge strengthen the river purification, which can improve the water quality
Score	2: The river network system improvement brings very positive impact by strengthening the river purification and finally improve the water quality, and after the river layout changing, the water can be improved sustainably

    b. Sewerage project

Pressure	Change the pipe network layout
State	The layout of river changing can also change the layout of storm water pipe
Impact	No impact to water quality
Score	0: The change of river layout have no impact to the sewerage project on the water quality improvement

    c. Sanitation project:

Pressure	Change the garbage bins places
State	The sanitation project remains the same state
Impact	No impact to water quality
Score	0: The river network system improvement brings no impact to sanitation project

    d. River chief system:

Pressure	Increase the discharge rate of rivers and decrease the river sludge
State	There is no black-smelly river
Impact	Increase the self-purification of rivers
Score	2: The river water can be improved and the river chief has less stress. And the water quality is improved directly. So the impact to river chief is very strong

    e. Wetland construction:

Pressure	Increase the amount of water which the wetland need to treat
State	The wetland can be used to clean the river water
Impact	The water quality can be improved

Score	1: The river network brings positive impact to wetland construction by reducing the difficulty in wetland treatment to improve the water quality. But it depends on the design capacity of wetland

7. Wetland construction
    a. Flood protection project

Pressure	Reduced the rate of surface runoff
State	Some flood may not happen or the intensity of the flood can decrease
Impact	The water quality can be improved
Score	1: The wetland construction brings positive impact to flood protection project by reducing the flood intensity to improve the water quality, but it is limited by the wetland design capacity

    b. Sewerage project

Pressure	Increase the outflow quality of WWTP
State	The outflow of WWTP can achieve the standard
Impact	The outflow cannot affect the water quality
Score	2: The wetland construction brings very positive impact to sewerage project by increasing the outflow water quality to improve the river water quality

    c. Sanitation project:

Pressure	Change the flushing water type
State	The public toilet can use the water which is after the wetland treatment
Impact	Reuse the water
Score	2: The wetland construction brings very positive impact to sanitation project by reusing the water to reduce the water pollutant discharge

    d. River chief system:

Pressure	Increase the self-purification of rivers
State	The rivers keeps clean
Impact	The river chief has less stress
Score	2: The river water can be improved and the river chief has less stress. And the water quality is improved directly, so the impact to river chief is very strong

    e. River network system improvement:

Pressure	Improve river water ecological environment
State	Increase the river water self-purification ability
Impact	The river water is improved
Score	2: The wetland construction brings very positive impact to river network system improvement by increasing the river water self-purification ability to reduce the difficulty of river cleaning

In conclusion, the total result of connection in base scenario is shown as **Error! Reference source not found.** in Annex D

Scenario Ⅰ

1. Flood protection project
    a. Sewerage project:

Pressure	The flood risk decrease
State	Surface water level decrease
Impact	There is no overflow of sewer pipe, which will not cause damage to the road and affect the water quality
Score	0: If there is no flood protection project, the overflow only exists in extreme events. But with the large green land help to delay water, the flood will not affect the sewerage water project. So the construction of flood protection project will have no impact to the sewerage project, as well as the quality

    b. Sanitation project:

Pressure	The flood risk decrease
State	The sanitation facilities will not suffer from the flood
Impact	The sanitation facilities remain the same
Score	0: The change of the pressure has no impact to the sanitation project, as well as the water quality

    c. River chief system:

Pressure	Decrease the flood risk
State	The river chief doesn't have to face the water quality deterioration caused by flood
Impact	The river chief has less stress
Score	0: The large green area serve a buffer for the storm water, so the flood protection project has no effect on river water quality

    d. River network system improvement:

Pressure	The flood risk decrease
State	The land sediments will not move to river and the river sludge will not increase
Impact	The water quality will be improved
Score	0: Even in extreme events, there is large green land to delay water, which means the lack of flood protection project will not affect the river layout. So the construction of flood protection has no impact to the river network system improvement

e. Wetland construction:

Pressure	The flood risk decrease
State	The wetland will not be used to store water and delay surface water, and can be used for other function such as clean the river water
Impact	The river water can be cleaned
Score	1: The construction of flood protection brings positive impact to wetland, and the water quality improvement only act when the wetland is used to clean water

2. Sewerage project
    a. Flood protection project

Pressure	The dry weather flow will be discharged to WWTP steadily
State	The dry weather flow will not be a part of flood
Impact	The water quality will not be disturbed by flood
Score	1: The sewerage project should bring very positive impact to flood protection protect due to the water quality is improved at all times. But the large green land can be used to storage flood, so the sewerage project has less effect, then it brings positive impact to flood protection project.

    b. Sanitation project:

Pressure	Change the sewerage system of public toilet from combined system to separation system
State	The sewage of public toilet will be discharged to WWTP
Impact	The water quality will not be disturbed by sewage
Score	1: The sewerage project brings positive impact to sanitation project. If there is no sewerage project, in raining days, the overflow may contains the sewage and affect the water quality 2: The construction of sewerage project brings very positive impact to sanitation project by reducing the possibility of sewage overflow to improve the water quality at all times

    c. River chief system:

Pressure	Eliminated the risk of overflow of sewer
State	The river chief doesn't have to face the water quality deterioration caused by overflow of sewer
Impact	The river chief has less stress
Score	1: Although the large green area can delay the overflow of sewer pipe, the tourism can increase the water use, which means there is a lot of sewerage in the pipe, so the overflow may still affect the water quality, which still lead stress to river chief. So the construction of sewerage project has positive impact to river chief system, but it is not very strong

    d. River network system improvement:

Pressure	Eliminated the risk of overflow of sewer
State	The river will not affected by waste water and
Impact	The difficulty of clearing the river will not increase so the river water keeps clean
Score	1: The sewerage project brings positive impact to river network system improvement. It will not discharge the sewer to the river at all times, the river water will not be affected. But the large green area can purify sewage

	before it flows into the river if there is still the combined system, so the level of positive impact it brings will drop by one level, which is from very positive impact to positive impact

e. Wetland construction:

Pressure	Increase the storm water quantity
State	The wetland need to treat more storm water
Impact	The life period of wetland will be reduced, which will reduce the water quality
Score	0: The construction of sewerage project brings negative impact to the wetland by reducing the life period, and the damage to wetlands can eventually affect water quality after a while. But the damage can be considered negligible with large green land

3. Sanitation project
   a. Flood protection project

Pressure	Reduce the amount of garbage floating on the river
State	The river for flood storage is clean and there is no increasing river sludge
Impact	The river water is improved
Score	1: The sanitation project brings very positive impact to the flood protection project by reducing the river sludge, which will improve the river quality at last at all times. But the increasing tourists may also increase the amount of garbage, which means the river is inevitable to be polluted by some rubbish

   b. Sewerage project

Pressure	Increase the amount of waste water
State	The WWTP is busy
Impact	The river water may be pollutant by outflow of WWTP
Score	-2: The sanitation project brings negative impact to sewerage project, and the outflow of WWTP which cannot achieve the standard due to the large amount of waste water treatment because of the tourism development

   c. River chief system:

Pressure	Reduce the garbage on the river
State	The river chief doesn't have to face the water quality deterioration caused by garbage
Impact	The river chief has less stress
Score	2: The tourism development increase the amount of garbage, so the construction of sanitation project reduce the garbage on the river, which not only improve the water quality, but also reduce the stress of river chief

d. River network system improvement:

Pressure	Decrease the garbage on the river
State	The river surface is clean
Impact	The river sludge will not increase
Score	1: The sanitation project brings positive impact to river network system improvement by decreasing the garbage to reduce the river sludge, then the difficulty of river cleaning will also be reduced. And the increasing tourists will have the uncivilized behaviour, which may let the tourists throw the garbage into the river, and there may be no time for scenic staff to salvage, which means the water quality can be improved in a limit condition

e. Wetland construction:

Pressure	Reducing the garbage dump on wetland
State	The wetland works as normal
Impact	The wetland can be used to clean water to improve the water quality
Score	1: The sanitation project brings very positive impact to wetland construction by reducing the possibility of wetland damage, but due to the increasing tourists, the increasing garbage may still cause some damage to the wetland. So the water quality improvement has the limit

4. River chief system
   a. Flood protection project

Pressure	Speed up construction
State	Flood protection project will be completed in advance
Impact	The flood project can be used in advance
Score	1: River chief system brings positive impact to flood protection project. The flood construction cannot improve the water quality directly, so only some river chief will push to construct the flood protection project. So the water quality can be improved, but it depend on the river chief

e. Sewerage project

Pressure	Speed up construction
State	Sewerage project will be completed in advance
Impact	The sewerage project can be used in advance, so the water quality will be improved
Score	2: River chief system brings very positive impact to sewerage project by constructing the project in advance, which means the water will be improved easier. In addition, the sewerage project can improve the water quality directly, so the river chief is willing to construct it

f. Sanitation project:

Pressure	Speed up construction
State	Sanitation project will be completed in advance
Impact	The sanitation project can be used in advance
Score	2: River chief system brings positive impact to sanitation project by constructing the project in advance, which means the water will be improved easier. Although the sanitation project doesn't improve the water quality directly, the development of tourism will let the river chief to reduce the possible pollutant from tourists

g. River network system improvement:

Pressure	Speed up construction
State	River network system improvement will be completed in advance
Impact	The river can has higher discharge and be cleaner in advance
Score	2: River chief system brings very positive impact to river network system improvement by constructing the project in advance, which means the water will be improved easier. In addition, river network system improvement can improve the water quality directly, so the river chief is willing to construct it

h. Wetland construction:

Pressure	Speed up construction
State	Wetland construction will be completed in advance
Impact	Wetland can be used in advance
Score	2: River chief system brings very positive impact to wetland construction by constructing the project in advance, which means the water will be improved easier. In addition Wetland construction can improve the water quality directly, so the river chief is willing to construct it

5. River network system improvement
   a. Flood protection project

Pressure	Layout changing decrease the flood risk
State	Some flood will not happen
Impact	The increasing river discharge strengthen the river purification, which will improve the water quality
Score	2: The river network system improvement brings very positive impact by strengthening the river purification and finally improve the water quality, and after the river layout changing, the water can be improved sustainably

b. Sewerage project

Pressure	Change the pipe network layout

State	The layout of river changing will also change the layout of storm water pipe
Impact	No impact to water quality
Score	0: The change of river layout have no impact to the sewerage project on the water quality improvement

c. Sanitation project:

Pressure	Change the garbage bins places
State	The sanitation project remains the same state
Impact	No impact to water quality
Score	0: The river network system improvement brings no impact to sanitation project

d. River chief system:

Pressure	Increase the discharge rate of rivers and decrease the river sludge
State	There is no black-smelly river
Impact	Increase the self-purification of rivers
Score	0: The large green area help rivers to strengthen the self-purification of rivers, so the river network system improvement has little impact on the improvement of water quality. And the river chief have no stress

e. Wetland construction:

Pressure	Increase the amount of water which the wetland need to treat
State	The wetland will be used to clean the river water
Impact	The water quality can be improved
Score	2: The river network brings positive impact to wetland construction by reducing the difficulty in wetland treatment to improve the water quality. And the large green area will also reduce the possible damage to wetland

6. Wetland construction
    a. Flood protection project

Pressure	Reduced the rate of surface runoff
State	Some flood may not happen or the intensity of the flood will decrease
Impact	The water quality will be improved
Score	2: The wetland construction brings positive impact to flood protection project by reducing the flood intensity to improve the water quality. And the large green land also gives good opportunity to construct wetland

    b. Sewerage project

Pressure	Increase the outflow quality of WWTP
State	The outflow of WWTP can achieve the standard
Impact	The outflow will not affect the water quality
Score	2: The wetland construction brings very positive impact to sewerage project by increasing the outflow water quality to improve the river water quality

c. Sanitation project:

Pressure	Change the flushing water type
State	The public toilet can use the water which is after the wetland treatment
Impact	Reuse the water
Score	2: The wetland construction brings very positive impact to sanitation project by reusing the water to reduce the water pollutant discharge

d. River chief system:

Pressure	Strengthen the self-purification of rivers
State	The rivers keeps clean
Impact	The river chief has less stress
Score	0: The large green area help rivers to strengthen the self-purification of rivers, so the wetland construction has little impact on the improvement of water quality. And the river chief have no stress

e. River network system improvement:

Pressure	Improve river water ecological environment
State	Increase the river water self-purification ability
Impact	The river water is improved
Score	2: The wetland construction brings very positive impact to river network system improvement by increasing the river water self-purification ability to reduce the difficulty of river cleaning

Scenario II

1. Flood protection project

    a. Sewerage project:

Pressure	The flood risk decrease
State	Surface water level decrease
Impact	There is no overflow of sewer pipe, which will not cause damage to the road and affect the water quality.
Score	1: If there is no flood protection project, the overflow only exists in extreme events. And the less green land cannot help to delay water. So the construction of flood protection project will have positive impact to the sewerage project, as well as the quality.

    b. Sanitation project:

Pressure	The flood risk decrease
State	The sanitation facilities will not suffer from the flood
Impact	The sanitation facilities remain the same
Score	0: The change of the pressure has no impact to the sanitation project, as well as the water quality.

    c. River chief system:

Pressure	Decrease the flood risk
State	The river chief doesn't have to face the water quality deterioration caused by flood
Impact	The river chief has less stress
Score	1: The small green area cannot serve a buffer for the storm water, so the flood protection project has effect on flood storage, and improve the water quality to decrease the stress of river chief. But the water quality is not improved directly, so the positive impact to river chief is not strong.

    d. River network system improvement:

Pressure	The flood risk decrease
State	The land sediments will not move to river and the river sludge will not increase
Impact	The water quality will be improved
Score	2: The construction of flood protection bring very positive impact to the river network system improvement by reducing the sediments in the river. So the water quality is improved at all times.

    e. Wetland construction:

Pressure	The flood risk decrease
State	The wetland will not be used to store water and delay surface water, and can be used for other function such as clean the river water
Impact	The river water can be cleaned
Score	1: The construction of flood protection brings positive impact to wetland, and the water quality improvement only act when the wetland is used to clean river water.

2. Sewerage project

a. Flood protection project

Pressure	The dry weather flow will be discharged to WWTP steadily
State	The dry weather flow will not be a part of flood
Impact	The water quality will not be disturbed by flood
Score	2: The sewerage project brings very positive impact to flood protection protect by discharging the wet weather flow to the WWTP. When the flood is coming, the domestic waste water cannot enter the river with flood, so the river water will not be polluted at all times.

b. Sanitation project:

Pressure	Eliminated the risk of overflow of sewer
State	The sewerage system of public toilet is changed from combined system to separation system
Impact	The water quality will not be disturbed by sewage
Score	2: The construction of sewerage project brings very positive impact to sanitation project by reducing the large amount of sewage overflow due to the tourism development, which can improve the water quality at all times

c. River chief system:

Pressure	Eliminated the risk of overflow of sewer
State	The river chief doesn't have to face the water quality deterioration caused by overflow of sewer
Impact	The river chief has less stress
Score	2: the tourism can increase the water use, which means there is a lot of sewerage in the pipe, so the overflow may affect the water quality, which still lead stress to river chief. And the small green area cannot delay the overflow of sewer pipe, So the construction of sewerage project has very positive impact to river chief system.

d. River network system improvement:

Pressure	Eliminated the risk of overflow of sewer
State	The river will not affected by waste water
Impact	The difficulty of the river clean will not increase
Score	2: The sewerage project brings very positive impact to river network system improvement, because it will not discharge the sewer to the river at all times, the river water will not be affected. And the less green area has little effect on the purifying the sewer water.

e. Wetland construction:

Pressure	Increase the storm water quantity
State	The wetland need to treat more storm water
Impact	The life period of wetland will be reduced, which will reduce the water quality
Score	-2: The construction of sewerage project brings very negative impact to the wetland by reducing the life period, and the little green area cannot afford the requirement of storm water cleaning. So the damage to wetlands can eventually affect water quality immediately.

3. Sanitation project

a. Flood protection project

Pressure	Reduce the amount of garbage floating on the river
State	The river have enough space for flood storage and there is no increasing river sludge
Impact	The river water is improved
Score	1: The sanitation project brings very positive impact to the flood protection project by reducing the river sludge, which will improve the river quality at last at all times. But the increasing tourists may also increase the amount of garbage, which means the river is inevitable to be polluted by some rubbish

b. Sewerage project

Pressure	Increase the amount of waste water
State	The WWTP is busy
Impact	The river water may be pollutant by outflow of WWTP
Score	-2: The sanitation project brings negative impact to sewerage project, and the outflow of WWTP which cannot achieve the standard due to the large amount of waste water treatment because of the tourism development.

c. River chief system:

Pressure	Reduce the garbage on the river
State	The river chief doesn't have to face the water quality deterioration caused by garbage
Impact	The river chief has less stress
Score	2: The tourism development increase the amount of garbage, so the construction of sanitation project reduce the garbage on the river, which not only improve the water quality, but also reduce the stress of river chief.

d. River network system improvement:

Pressure	Decrease the garbage on the river
State	The river surface is clean
Impact	The river sludge will not increase
Score	1: The sanitation project brings positive impact to river network system improvement by decreasing the garbage to reduce the river sludge, then the difficulty of river cleaning will also be reduced. And the increasing tourists will have the uncivilized behaviour, which may let the tourists throw the garbage into the river, and there may be no time for scenic staff to salvage, which means the water quality can be improved in a limit condition. -2: The construction of sanitation project will increase the domestic sewage water due to the tourism development, which may cause the eutrophication in river and increase the pressure of river cleaning.

e. Wetland construction:

Pressure	Reducing the garbage dump on wetland
State	The wetland works as normal
Impact	The wetland can be used to clean water to improve the water quality
Score	1: The sanitation project brings very positive impact to wetland construction by reducing the possibility of wetland damage, but due to the increasing tourists, the increasing garbage may still cause some damage to the wetland. So the water quality improvement has the limit.

4. River chief system

a. Flood protection project

Pressure	Speed up construction
State	Flood protection project will be completed in advance
Impact	The flood project can be used in advance

Score	1: River chief system brings positive impact to flood protection project. The flood construction cannot improve the water quality directly, only some river chief will push to construct the flood protection project. So the water quality can be improved, but it depend on the river chief.

b. Sewerage project

Pressure	Speed up construction
State	Sewerage project will be completed in advance
Impact	The sewerage project can be used in advance, so the water quality will be improved
Score	2: River chief system brings very positive impact to sewerage project by constructing the project in advance, which means the water will be improved easier. In addition, the sewerage project can improve the water quality directly, so the river chief is willing to construct it

c. Sanitation project:

Pressure	Speed up construction
State	Sanitation project will be completed in advance
Impact	The sanitation project can be used in advance
Score	2: River chief system brings positive impact to sanitation project by constructing the project in advance, which means the water will be improved easier. Although the sanitation project doesn't improve the water quality directly, the development of tourism will let the river chief to reduce the possible pollutant from tourists

d. River network system improvement:

Pressure	Speed up construction
State	River network system improvement will be completed in advance
Impact	The river can has higher discharge and be cleaner in advance
Score	2: River chief system brings very positive impact to river network system improvement by constructing the project in advance, which means the water will be improved easier. In addition, river network system improvement can improve the water quality directly, so the river chief is willing to construct it

e. Wetland construction:

Pressure	Speed up construction
State	Wetland construction will be completed in advance
Impact	Wetland can be used in advance

Score	1: River chief system brings very positive impact to wetland construction by constructing the project in advance, which means the water will be improved easier. Although wetland can improve the water quality directly, and the river chief is willing to construct it, the less green area will limit the construction of wetland. So the improvement of water quality is limited.

5. River network system improvement

a. Flood protection project

Pressure	Layout changing decrease the flood risk
State	Some flood will not happen
Impact	The increasing river discharge strengthen the river purification, which will improve the water quality
Score	2: The river network system improvement brings very positive impact by strengthening the river purification and finally improve the water quality, and after the river layout changing, the water can be improved sustainably.

b. Sewerage project

Pressure	Change the pipe network layout
State	The layout of river changing will also change the layout of storm water pipe
Impact	No impact to water quality
Score	0: The change of river layout have no impact to the sewerage project on the water quality improvement.

c. Sanitation project:

Pressure	Change the garbage bins places
State	The sanitation project remains the same state
Impact	No impact to water quality
Score	0: The river network system improvement brings no impact to sanitation project.

d. River chief system:

Pressure	Increase the discharge rate of rivers and decrease the river sludge
State	There is no black-smelly river
Impact	Increase the self-purification of rivers
Score	2: The small green area cannot help rivers to strengthen the self-purification of rivers, so the river network system improvement has very

	positive impact on the improvement of water quality. And the river chief have less stress.

e. Wetland construction:

Pressure	Increase the amount of water which the wetland need to treat
State	The wetland will be used to clean the river water
Impact	The water quality can be improved
Score	-2: The river network brings positive impact to wetland construction by reducing the difficulty in wetland treatment to improve the water quality. And the large green area will also reduce the possible damage to wetland

6. Wetland construction

a. Flood protection project

Pressure	Reduced the discharge of surface runoff
State	Some flood may not happen or the intensity of the flood will decrease
Impact	The water quality will be improved
Score	0: The less green land has little effect on reducing the discharge of surface runoff, so it has no impact to the flood protection project.

b. Sewerage project

Pressure	Increase the outflow quality of WWTP
State	The outflow of WWTP can achieve the standard
Impact	The outflow will not affect the water quality
Score	-2: The less green area has little effect on water cleaning, and the increasing water use makes the WWTP busy. Then the outflow of WWTP cannot achieve the standard, which will deteriorate the water quality at all times.

c. Sanitation project:

Pressure	Change the flushing water type
State	The public toilet can use the water which is after the wetland treatment
Impact	Reuse the water
Score	0: The less green area has little effect on water clean, which means that the public toilet cannot use the water from wetland. So the wetland construction has no impact to sanitation project.

d. River chief system:

Pressure	Strengthen the self-purification of rivers
State	The rivers keeps clean

Impact	The river chief has less stress
Score	0: The small green area cannot help rivers to strengthen the self-purification of rivers, and the wetland construction also depends on the green area, so the wetland has little effect on the improvement of water quality, and the river chief need to put forward to other measures.

e. River network system improvement:

Pressure	Improve river water ecological environment
State	Increase the river water self-purification ability
Impact	The river water is improved
Score	0: The small green area has little effect on the river water clean. So the wetland construction has no impact to river network system improvement.

Scenario III

1. Flood protection project
    a. Sewerage project:

Pressure	The flood risk decrease
State	Surface water level decrease
Impact	There is no overflow of sewer pipe, which will not cause damage to the road and affect the water quality.
Score	1: If there is no flood protection project, the overflow only exists in extreme events. And the less green land cannot help to delay water. So the construction of flood protection project will have positive impact to the sewerage project, as well as the quality.

b. Sanitation project:

Pressure	The flood risk decrease
State	The sanitation facilities will not suffer from the flood
Impact	The sanitation facilities remain the same
Score	0: The change of the pressure has no impact to the sanitation project, as well as the water quality.

c. River chief system:

Pressure	Decrease the flood risk
State	The river chief doesn't have to face the water quality deterioration caused by flood
Impact	The river chief has less stress
Score	1: The small green area cannot serve a buffer for the storm water, so the flood protection project has effect on flood storage, and improve the water

	quality to decrease the stress of river chief. But the water quality is not improved directly, so the positive impact to river chief is not strong.

d. River network system improvement:

Pressure	The flood risk decrease
State	The land sediments will not move to river and the river sludge will not increase
Impact	The water quality will be improved
Score	2: The construction of flood protection bring very positive impact to the river network system improvement by reducing the sediments in the river. So the water quality is improved at all times.

e. Wetland construction:

Pressure	The flood risk decrease
State	The wetland will not be used to store water and delay surface water, and can be used for other function such as clean the river water
Impact	The river water can be cleaned
Score	1: The construction of flood protection brings positive impact to wetland, and the water quality improvement only act when the wetland is used to clean river water.

2. Sewerage project
   a. Flood protection project

Pressure	The dry weather flow will be discharged to WWTP steadily
State	The dry weather flow will not be a part of flood
Impact	The water quality will not be disturbed by flood
Score	1: The sewerage project brings very positive impact to flood protection protect by discharging the wet weather flow to the WWTP. When the flood is coming, the domestic waste water cannot enter the river with flood, so the river water will not be polluted.

   b. Sanitation project

Pressure	Eliminated the risk of overflow of sewer
State	The sewerage system of public toilet is changed from combined system to separation system
Impact	The water quality will not be disturbed by sewage
Score	1: The construction of sewerage project brings positive impact to sanitation project by reducing the overflow of sewage, which can improve the water quality.

   c. River chief system

Pressure	Eliminated the risk of overflow of sewer
State	The river chief doesn't have to face the water quality deterioration caused by overflow of sewer
Impact	The river chief has less stress
Score	2: the small green area cannot delay the overflow of sewer pipe, and the new waste water project can treat the industrial waste water well. So the construction of sewerage project has very positive impact to river chief system.

d. River network system improvement

Pressure	Eliminated the risk of overflow of sewer
State	The river will not affected by waste water
Impact	The difficulty of the river clean will not increase
Score	2: The sewerage project brings very positive impact to river network system improvement, because it will not discharge the sewer to the river at all times, the river water will not be affected. What's more, mostly the sewage water is the industry waste water, which is more toxic for the water. And the less green area has little effect on the purifying the sewer water.

e. Wetland construction

Pressure	Increase the storm water quantity
State	The wetland need to treat more storm water
Impact	The life period of wetland will be reduced, which will reduce the water quality
Score	-2: The construction of sewerage project brings very negative impact to the wetland by reducing the life period, and the little green area cannot afford the requirement of storm water cleaning. Sometimes some industries will pour their waste water into storm water pipe without permission, which deteriorate the wetland seriously. So the damage to wetlands can eventually affect water quality immediately.

3. Sanitation project
   a. Flood protection project

Pressure	Reduce the amount of garbage floating on the river
State	The river have enough space for flood storage and there is no increasing river sludge
Impact	The river water is improved
Score	2: The sanitation project brings very positive impact to the flood protection project by reducing the river sludge, which will improve the river quality at last at all times.

   b. Sewerage project

Pressure	Increase the amount of waste water
State	The WWTP is busy
Impact	The river water may be pollutant by outflow of WWTP
Score	0: The sewage treatment plant can treat the current sewage and there is no increasing water use, which means that the sanitation project will not affect the water quality and has no impact to sewerage project.

c. River chief system

Pressure	Reduce the garbage on the river
State	The river chief doesn't have to face the water quality deterioration caused by garbage
Impact	The river chief has less stress
Score	1: The construction of sanitation project can reduce the garbage on the river, but the village don't have much unmanaged garbage, so it doesn't reduce the stress of river chief much and has positive impact to river chief, but not strong.

d. River network system improvement

Pressure	Decrease the garbage on the river
State	The river surface is clean
Impact	The river sludge will not increase
Score	2: The sanitation project brings positive impact to river network system improvement by decreasing the garbage to reduce the river sludge, then the difficulty of river cleaning will also be reduced.

e. Wetland construction:

Pressure	Reducing the garbage dump on wetland
State	The wetland works as normal
Impact	The wetland can be used to clean water to improve the water quality
Score	2: the small green area is easy to be affected, so the sanitation project brings very positive impact to wetland construction by reducing the possibility of wetland damage

4. River chief system
    a. Flood protection project

Pressure	Speed up construction
State	Flood protection project will be completed in advance
Impact	The flood project can be used in advance
Score	1: River chief system brings positive impact to flood protection project. The flood construction cannot improve the water quality directly, only

	some river chief will push to construct the flood protection project. So the water quality can be improved, but it depend on the river chief.

b. Sewerage project

Pressure	Speed up construction
State	Sewerage project will be completed in advance
Impact	The sewerage project can be used in advance, so the water quality will be improved
Score	2: River chief system brings very positive impact to sewerage project by constructing the project in advance, which means the water will be improved easier. In addition, the sewerage project can improve the water quality directly, so the river chief is willing to construct it

c. Sanitation project:

Pressure	Speed up construction
State	Sanitation project will be completed in advance
Impact	The sanitation project can be used in advance
Score	1: River chief system brings very positive impact to sanitation project by constructing the project in advance, which means the water will be improved easier. But the sanitation project doesn't improve the water quality directly, so the it depends on the river chief

d. River network system improvement:

Pressure	Speed up construction
State	River network system improvement will be completed in advance
Impact	The river can has higher discharge and be cleaner in advance
Score	2: River chief system brings very positive impact to river network system improvement by constructing the project in advance, which means the water will be improved easier. In addition, river network system improvement can improve the water quality directly, so the river chief is willing to construct it

e. Wetland construction:

Pressure	Speed up construction
State	Wetland construction will be completed in advance
Impact	Wetland can be used in advance
Score	1: River chief system brings positive impact to wetland construction by constructing the project in advance, which means the water will be improved easier. However, Although wetland can improve the water quality directly, and the river chief is willing to construct it, the less green

	area will limit the construction of wetland. So the improvement of water quality is limited.

5. River network system improvement
    a. Flood protection project

Pressure	Layout changing decrease the flood risk
State	Some flood will not happen
Impact	The increasing river discharge strengthen the river purification, which will improve the water quality
Score	2: The river network system improvement brings very positive impact by strengthening the river purification and finally improving the water quality. After the river layout changing, the water can be improved sustainably. And the small green land area also cannot delay the storm water well, so the river network improvement works mostly

    b. Sewerage project

Pressure	Change the pipe network layout
State	The layout of river changing will also change the layout of storm water pipe
Impact	No impact to water quality
Score	0: The change of river layout have no impact to the sewerage project on the water quality improvement.

    c. Sanitation project:

Pressure	Change the garbage bins places
State	The sanitation project remains the same state
Impact	No impact to water quality
Score	0: The river network system improvement brings no impact to sanitation project.

    d. River chief system:

Pressure	Increase the discharge rate of rivers and decrease the river sludge
State	There is no black-smelly river
Impact	Increase the self-purification of rivers
Score	2: The small green area cannot help rivers to strengthen the self-purification of rivers, and the industry also discharge the pollutant to the river, so the river network system improvement has very positive impact to the improvement of water quality. And the river chief have less stress.

    e. Wetland construction:

Pressure	Increase the amount of water which the wetland need to treat
State	The wetland will be used to clean the river water

Impact	The water quality can be improved
Score	-2: The river network brings very negative impact to wetland construction by reducing the difficulty in wetland treatment to improve the water quality. And the large green area will also reduce the possible damage to wetland, what's more, some industry may connect the waste water to storm water pipe, which can deteriorate the river water much.

6. Wetland construction
    a. Flood protection project

Pressure	Reduced the discharge of surface runoff
State	Some flood may not happen or the intensity of the flood will decrease
Impact	The water quality will be improved
Score	0: The less green land has little effect on reducing the discharge of surface runoff, so it has no impact to the flood protection project.

    b. Sewerage project

Pressure	Increase the outflow quality of WWTP
State	The outflow of WWTP can achieve the standard
Impact	The outflow will not affect the water quality
Score	-2: The less green area has little effect on water cleaning, and the increasing water use makes the WWTP busy. Then the outflow of WWTP cannot achieve the standard, which will deteriorate the water quality at all times.

    c. Sanitation project:

Pressure	Change the flushing water type
State	The public toilet can use the water which is after the wetland treatment
Impact	Reuse the water
Score	0: The less green area has little effect on water clean, which means that the public toilet cannot use the water from wetland. So the wetland construction has no impact to sanitation project.

    d. River chief system:

Pressure	Strengthen the self-purification of rivers
State	The rivers keeps clean
Impact	The river chief has less stress
Score	0: The small green area cannot help rivers to strengthen the self-purification of rivers, and the wetland construction also depends on the green area, so the wetland has little effect on the improvement of water quality, and the river chief need to put forward to other measures.

    e. River network system improvement:

Pressure	Improve river water ecological environment
State	Increase the river water self-purification ability
Impact	The river water is improved
Score	0: The small green area has little effect on the river water clean. So the wetland construction has no impact to river network system improvement.

Scenario Ⅳ

1. Flood protection project
    a. Sewerage project:

Pressure	The flood risk decrease
State	Surface water level decrease
Impact	There is no overflow of sewer pipe, which cannot cause damage to the road and affect the water quality.
Score	0: If there is no flood protection project, the overflow only exists in extreme events. But with the large green land help to delay water, the flood cannot affect the sewerage water project. So the construction of flood protection project can have no impact to the sewerage project, as well as the quality.

    b. Sanitation project:

Pressure	The flood risk decrease
State	The sanitation facilities cannot suffer from the flood
Impact	The sanitation facilities remain the same
Score	0: The change of the pressure has no impact to the sanitation project, as well as the water quality.

    c. River chief system:

Pressure	Decrease the flood risk
State	The river chief doesn't have to face the water quality deterioration caused by flood
Impact	The river chief has less stress
Score	0: The large green area serve a buffer for the storm water, so the flood protection project has no effect on river water quality.

    d. River network system improvement:

Pressure	The flood risk decrease
State	The land sediments cannot move to river and the river sludge cannot increase
Impact	The water quality can be improved

Score	0: Even in extreme events, there is large green land to delay water, which means the lack of flood protection project cannot affect the river layout. So the construction of flood protection has no impact to the river network system improvement.

e. Wetland construction:

Pressure	The flood risk decrease
State	The wetland cannot be used to store water and delay surface water, and can be used for other function such as clean the river water
Impact	The river water can be cleaned
Score	1: The construction of flood protection brings positive impact to wetland, and the water quality improvement only act when the wetland is used to clean water.

2. Sewerage project
   a. Flood protection project

Pressure	The dry weather flow can be discharged to WWTP steadily
State	The dry weather flow cannot be a part of flood
Impact	The water quality cannot be disturbed by flood
Score	1: The sewerage project should bring positive impact to flood protection protect due to the water quality is improved at all times. But the large green land can be used to storage flood, so the sewerage project has less effect, then it brings positive impact to flood protection project, as well as the water quality.

b. Sanitation project:

Pressure	Change the sewerage system of public toilet from combined system to separation system
State	The sewage of public toilet can be discharged to WWTP
Impact	The water quality cannot be disturbed by sewage
Score	1: The sewerage project brings positive impact to sanitation project. If there is no sewerage project, in raining days, the overflow may contains the sewage and affect the water quality. 2: The construction of sewerage project brings very positive impact to sanitation project by reducing the possibility of sewage overflow to improve the water quality at all times.

c. River chief system:

Pressure	Eliminated the risk of overflow of sewer
State	The river chief doesn't have to face the water quality deterioration caused by overflow of sewer

Impact	The river chief has less stress
Score	1: The large green area can delay the overflow of sewer pipe, but the industrial waste water affect the water quality much. So the construction of sewerage project has positive impact to river chief system, but it is not very strong.

d. River network system improvement:

Pressure	Eliminated the risk of overflow of sewer
State	The river cannot affected by waste water and
Impact	The difficulty of clearing the river cannot increase so the river water keeps clean
Score	1: The sewerage project brings positive impact to river network system improvement. It cannot discharge the sewer to the river at all times, the river water cannot be affected. But the large green area can purify sewage before it flows into the river if there is still the combined system, and the industry may connect the waste water to storm water pipe without permission. So the level of positive impact it brings can drop by one level, which is from very positive impact to positive impact

e. Wetland construction:

Pressure	Increase the storm water quantity
State	The wetland need to treat more storm water
Impact	The life period of wetland can be reduced, which can reduce the water quality
Score	0: The construction of sewerage project brings positive impact to the wetland by reducing the life period, and the damage to wetlands can eventually affect water quality after a while. But the damage can be considered negligible with large green land.

3. Sanitation project
   a. Flood protection project

Pressure	Reduce the amount of garbage floating on the river
State	The river for flood storage is clean and there is no increasing river sludge
Impact	The river water is improved
Score	2: The sanitation project brings very positive impact to the flood protection project by reducing the river sludge, which can improve the river quality at last at all times.

b. Sewerage project

Pressure	Increase the amount of waste water
State	The WWTP is busy

Impact	The river water may be pollutant by outflow of WWTP
Score	0: The sewage treatment plant can treat the current sewage and there is no increasing water use, which means that the sanitation project cannot affect the water quality and has no impact to sewerage project.

c. River chief system:

Pressure	Reduce the garbage on the river
State	The river chief doesn't have to face the water quality deterioration caused by garbage
Impact	The river chief has less stress
Score	1: The construction of sanitation project can reduce the garbage on the river, but the village don't have much unmanaged garbage, so it doesn't reduce the stress of river chief much and has positive impact to river chief, but not strong.

d. River network system improvement:

Pressure	Decrease the garbage on the river
State	The river surface is clean
Impact	The river sludge cannot increase
Score	1: The sanitation project brings positive impact to river network system improvement by decreasing the garbage to reduce the river sludge, then the difficulty of river cleaning can also be reduced.

e. Wetland construction:

Pressure	Reducing the garbage dump on wetland
State	The wetland works as normal
Impact	The wetland can be used to clean water to improve the water quality
Score	1: The sanitation project brings very positive impact to wetland construction by reducing the possibility of wetland damage, but due to the increasing tourists, the increasing garbage may still cause some damage to the wetland. So the water quality improvement has the limit.

4. River chief system
    a. Flood protection project

Pressure	Speed up construction
State	Flood protection project can be completed in advance
Impact	The flood project can be used in advance
Score	1: River chief system brings positive impact to flood protection project. The flood construction cannot improve the water quality directly, so only some river chief can push to construct the flood protection project. So the water quality can be improved, but it depend on the river chief

    b. Sewerage project

Pressure	Speed up construction
State	Sewerage project can be completed in advance
Impact	The sewerage project can be used in advance, so the water quality can be improved
Score	2: River chief system brings very positive impact to sewerage project by constructing the project in advance, which means the water can be improved easier. In addition, the sewerage project can improve the water quality directly, so the river chief is caning to construct it

    c. Sanitation project:

Pressure	Speed up construction
State	Sanitation project can be completed in advance
Impact	The sanitation project can be used in advance
Score	1: River chief system brings positive impact to sanitation project by constructing the project in advance, which means the water can be improved easier. But the sanitation project doesn't improve the water quality directly, so it depends on the river chief

    d. River network system improvement:

Pressure	Speed up construction
State	River network system improvement can be completed in advance
Impact	The river can has higher discharge and be cleaner in advance
Score	2: River chief system brings very positive impact to river network system improvement by constructing the project in advance, which means the water can be improved easier. In addition, river network system improvement can improve the water quality directly, so the river chief is caning to construct it

    e. Wetland construction:

Pressure	Speed up construction

State	Wetland construction can be completed in advance
Impact	Wetland can be used in advance
Score	2: River chief system brings very positive impact to wetland construction by constructing the project in advance, which means the water can be improved easier. In addition Wetland construction can improve the water quality directly, so the river chief is caning to construct it

5. River network system improvement
    a. Flood protection project

Pressure	Layout changing decrease the flood risk
State	Some flood cannot happen
Impact	The increasing river discharge strengthen the river purification, which can improve the water quality
Score	2: The river network system improvement brings very positive impact by strengthening the river purification and finally improve the water quality, and after the river layout changing, the water can be improved sustainably.

    b. Sewerage project

Pressure	Change the pipe network layout
State	The layout of river changing can also change the layout of storm water pipe
Impact	No impact to water quality
Score	0: The change of river layout have no impact to the sewerage project on the water quality improvement.

    c. Sanitation project:

Pressure	Change the garbage bins places
State	The sanitation project remains the same state
Impact	No impact to water quality
Score	0: The river network system improvement brings no impact to sanitation project.

    d. River chief system:

Pressure	Increase the discharge rate of rivers and decrease the river sludge
State	There is no black-smelly river
Impact	Increase the self-purification of rivers
Score	1: The large green area help rivers to strengthen the self-purification of rivers, but the industrial waste water has much pollutant which need the waste water treatment plant to treat. So the river network system

	improvement has positive impact on the improvement of water quality. And the river chief have less stress.

e. Wetland construction:

Pressure	Increase the amount of water which the wetland need to treat
State	The wetland can be used to clean the river water
Impact	The water quality can be improved
Score	2: The river network brings positive impact to wetland construction by reducing the difficulty in wetland treatment to improve the water quality. And the large green area can also reduce the possible damage to wetland

6. Wetland construction
   a. Flood protection project

Pressure	Reduced the rate of surface runoff
State	Some flood may not happen or the intensity of the flood can decrease
Impact	The water quality can be improved
Score	2: The wetland construction brings positive impact to flood protection project by reducing the flood intensity to improve the water quality. And the large green land also gives good opportunity to construct wetland

b. Sewerage project

Pressure	Increase the outflow quality of WWTP
State	The outflow of WWTP can achieve the standard
Impact	The outflow cannot affect the water quality
Score	2: The wetland construction brings very positive impact to sewerage project by increasing the outflow water quality to improve the river water quality.

c. Sanitation project:

Pressure	Change the flushing water type
State	The public toilet can use the water which is after the wetland treatment
Impact	Reuse the water
Score	2: The wetland construction brings very positive impact to sanitation project by reusing the water to reduce the water pollutant discharge

d. River chief system:

Pressure	Strengthen the self-purification of rivers
State	The rivers keeps clean
Impact	The river chief has less stress

Score	0: The large green area help rivers to strengthen the self-purification of rivers, so the wetland construction has little impact on the improvement of water quality. And the river chief have no stress.

e. River network system improvement:

Pressure	Improve river water ecological environment
State	Increase the river water self-purification ability
Impact	The river water is improved
Score	2: The wetland construction brings very positive impact to river network system improvement by increasing the river water self-purification ability to reduce the difficulty of river cleaning

Annex D. Synergies, bottlenecks and connections in future scenarios

Synergies& bottlenecks map based on SWOT analysis:

The action analysis is based on the SWOT of every action in each scenario, whose detailed information is presented in Appendix-B. The synergies map and bottlenecks map is also based on the SWOT analysis in Appendix-B. The summary of SWOT analysis of every action in each scenario is shown below:

Scenario Ⅰ - High green area and economic dependence on tourism

In the river chief system, the river chief can balance the economic development and environmental protection easily and has more power. Because the environment is the key point in tourism development, so there is no conflict between environmental protection and economic development. Although it is hard to control the tourist behavior, it is not a big problem. The sewerage project, the waste water treatment plant, can improve the water quality of outflow by using the large green area. However, the increasing water use which is caused by tourism development is also a big challenge for the waste water treatment plant. In the flood protection project, the large green area offers enough space for storm water delay and storage, which can decrease the pressure of the flood protection project. In the sanitation project, the public sanitation facilities meet the requirements of tourism development, which can also increase tourists' experience. In the wetland construction, the large green land has enough space for the wetland. In addition, the wetland can also be a place for the tourists to visit. In the river network system improvement, cleaning the water is good for tourism development. Because people are attracted by the specific water culture in the water village, which means that the river water has an important impact on tourism. The synergies map and bottlenecks map are shown in Figure 3andFigure 4.

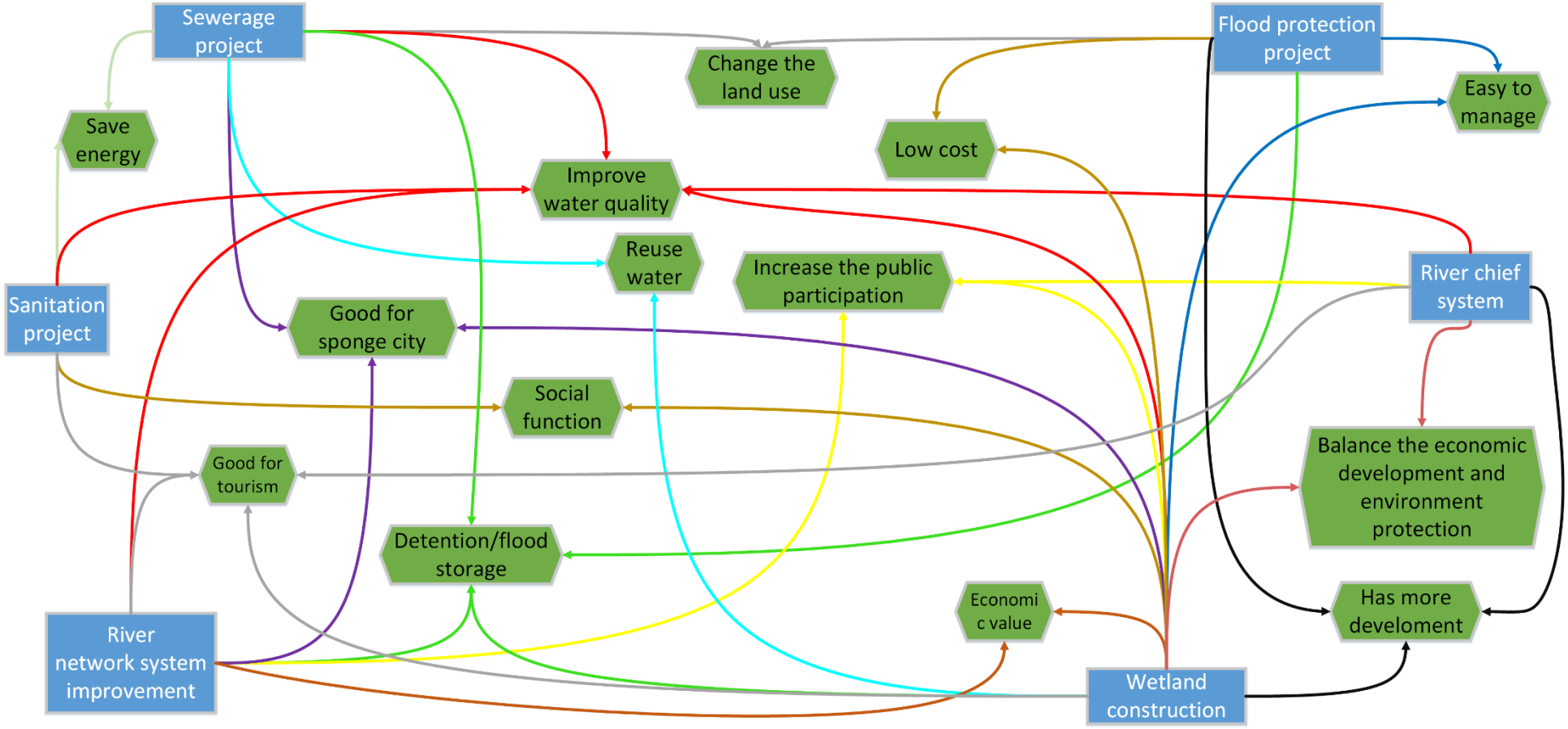


Figure 3 Synergy of actions in scenarios I

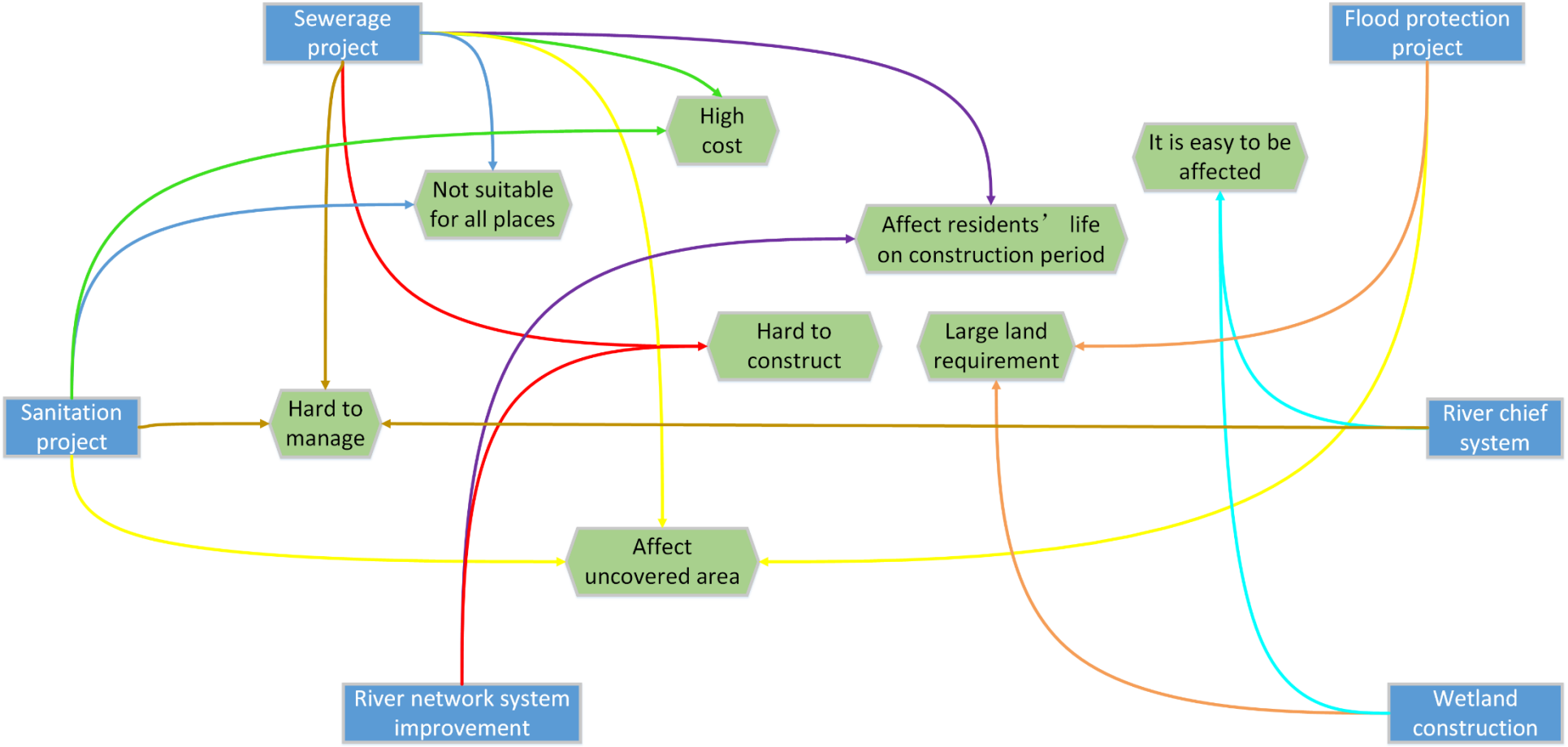


Figure 4 Bottlenecks of actions in scenario I

Scenario Ⅱ - Low green area and economic dependence on tourism

In the river chief system, the river chief can balance economic development and environmental protection easily and has more power. Because the environment is the key point in tourism development, so there is no conflict between environmental protection and economic development. However, the small green area limits the condition of water quality improvement. So the final result of water quality improvement can depend on the ability of the river chief. In the sewerage project, the increasing water use which is caused by tourism development is a big challenge for the waste water treatment plant, and the waste water treatment plant can only improve the chemical treatment process due to lack of the green area. In the flood protection project, the small green area cannot delay and store storm water. What's more, the water conservancy facilities may affect the biotic environment with a small green area. And the water level of downstream may also be affected. In the sanitation project, the public sanitation facilities meet the requirement of tourism development, which can also increase the tourists' experience. In the wetland construction, the small green area does not have enough space for the wetland, which also has little possibility for the tourists visiting. In the river network system improvement, clean the water is good for tourism development. Because people are attracted by the specific water culture in water village, which means that the river water has an important impact on tourism. But the small green area makes the river clean not suitable. The synergies map and bottlenecks map are shown as Figure 5andFigure 6.

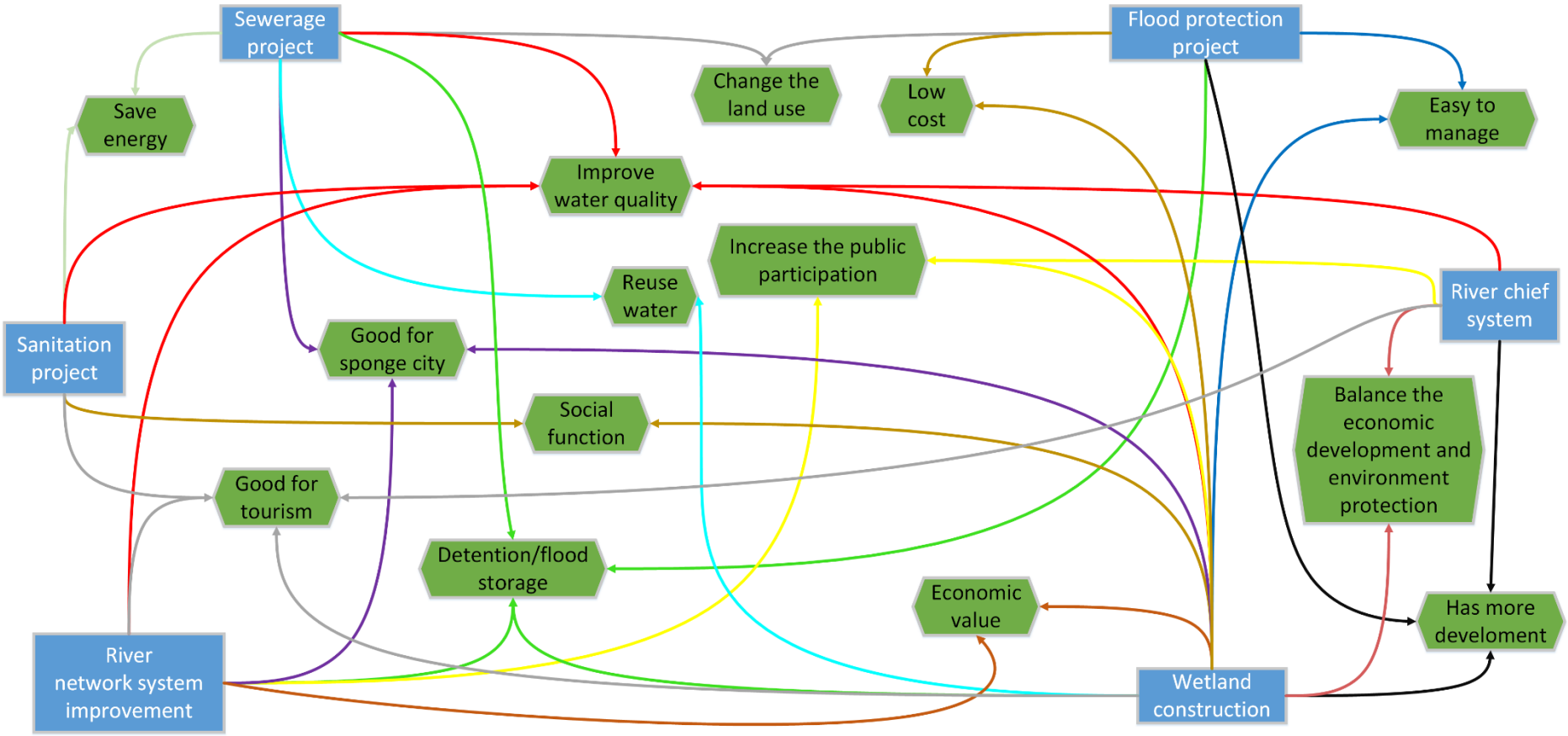


Figure 5 Synergy of actions in scenarios II

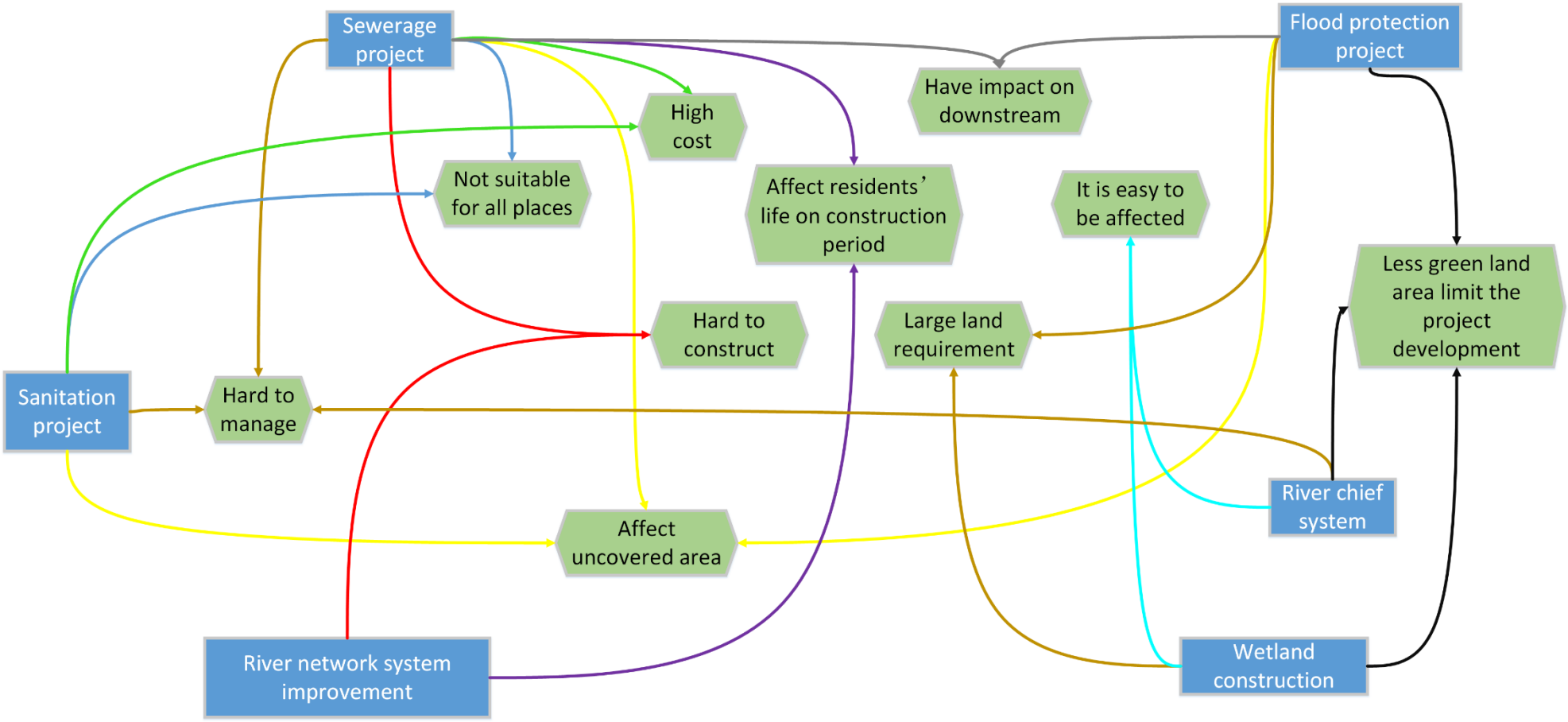


Figure 6 Bottlenecks of actions in scenario II

Scenario Ⅲ- Low green area and economic dependence on heavy industry

In the river chief system, it is hard for the river chief to balance economic development and environmental protection. Because the heavy industry is the main income of the economy, and it inevitably affects the water quality. And the river chief is also the government leader, so they also have to consider the economic development in the town. What's more, the small green area limits the condition of water quality improvement. So the final result of water quality improvement can depend on the ability of river chief. In the sewerage project, the waste water treatment plant needs to improve their treatment process to remove the pollutant from the industrial waste water, and the waste water treatment plant can only improve the chemical treatment process due to lack of the green area. In addition, the separation system can discharge the storm water into the river directly, which may affect the water quality of downstream. And some unpermitted private pipe connections of industry can cause high pollution in the river. In the flood protection project, the small green area cannot delay and store storm water. What's more, the water conservancy facilities may affect the biotic environment with a small green area. And the water level of downstream may also be affected. In the wetland construction, the small green area does not have enough space for the wetland, and it is hard to improve the surrounding environment of the industry. In the river network system improvement, river cleaning is not a sustainable way under the industry condition. And the small green area makes the river clean not sustainable. The synergies map and bottlenecks map are shown as Figure 7andFigure 8.

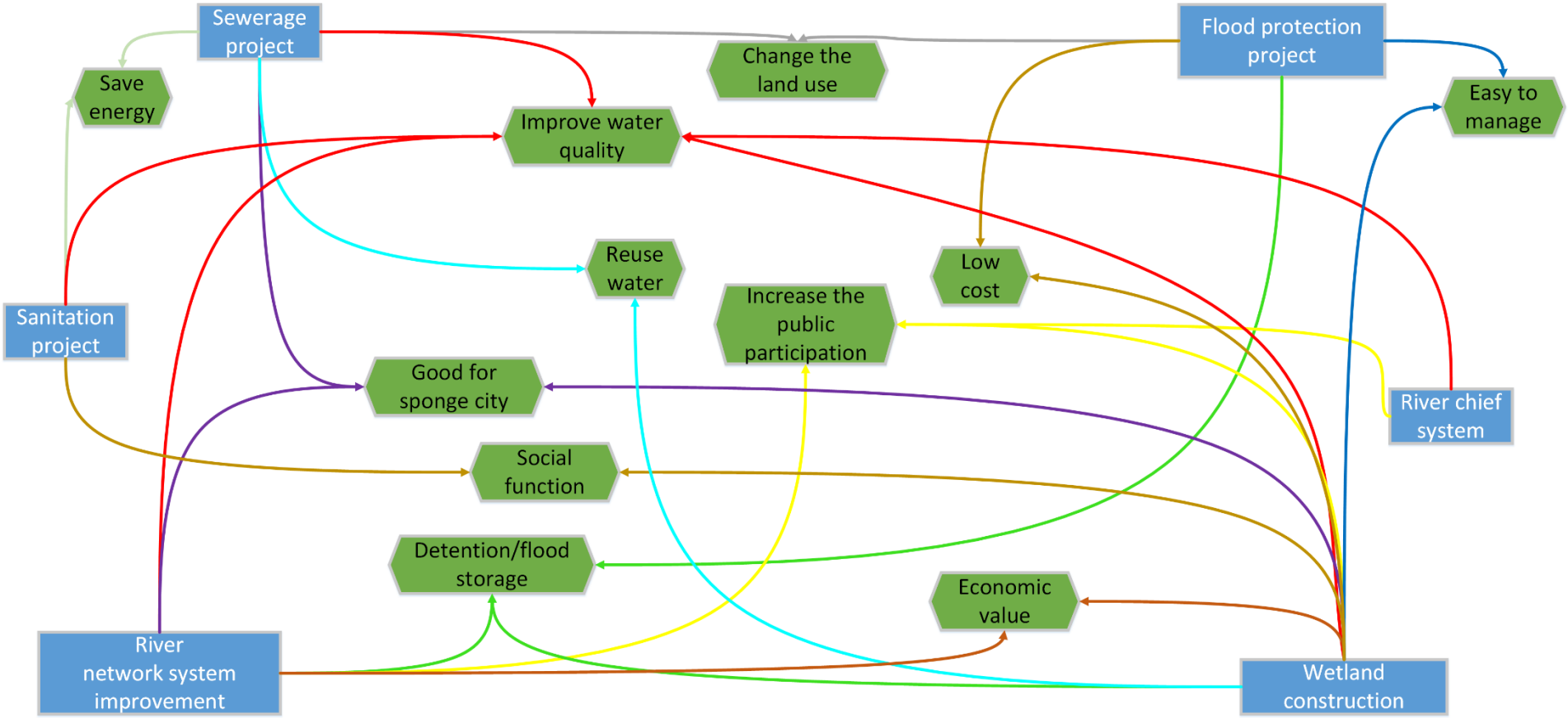


Figure 7 Synergy of actions in scenarios III

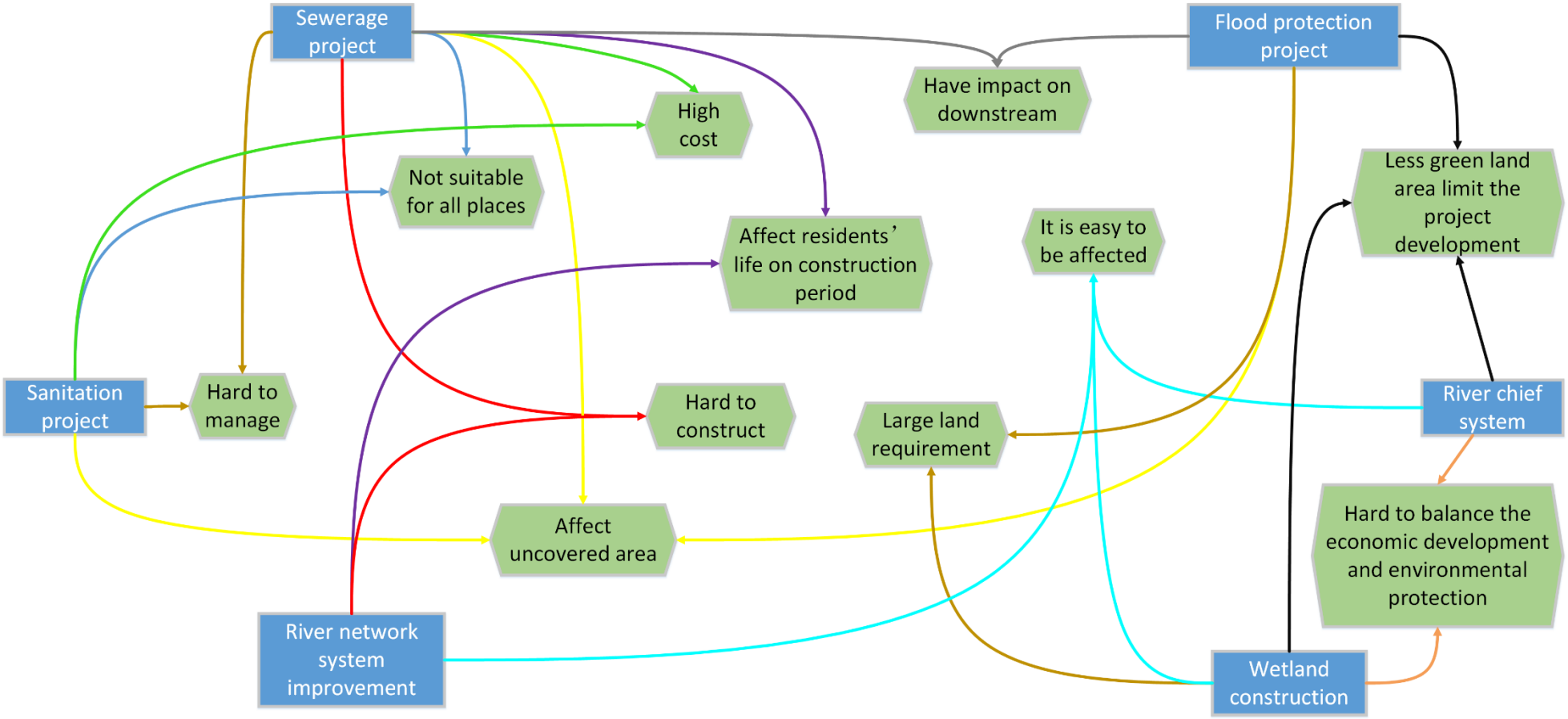


Figure 8 Bottlenecks of actions in scenario III

Scenario Ⅳ- High green area and economic dependence on heavy industry

In the river chief system, it is hard for the river chief to balance economic development and environmental protection. Because the heavy industry is the main income of the economy, and it inevitably affects the water quality. And the river chief is also the government leader, so they also have to consider the economic development in the town. But the large green area is helpful for water quality improvement. In the sewerage project, the waste water treatment plant needs to improve their treatment process to remove the pollutant from the industrial waste water, and the waste water treatment plant can only improve the chemical treatment process due to lack of the green area. In addition, the separation system can discharge the storm water into the river directly, which may affect the water quality of downstream. And some unpermitted private pipe connections of industry can cause high pollution in the river. In the flood protection project, the large green area offers enough space for storm water delay and storage, which can decrease the pressure of the flood protection project. In the wetland construction, the large green land has enough space for the wetland, which is also good to improve the surrounding environment of the industry. In the river network system improvement, river cleaning is not a sustainable way under the industry condition. But the large green area can increase the ability of self-purification in the river. The synergies map and bottlenecks map are shown as Figure 9andFigure 10.

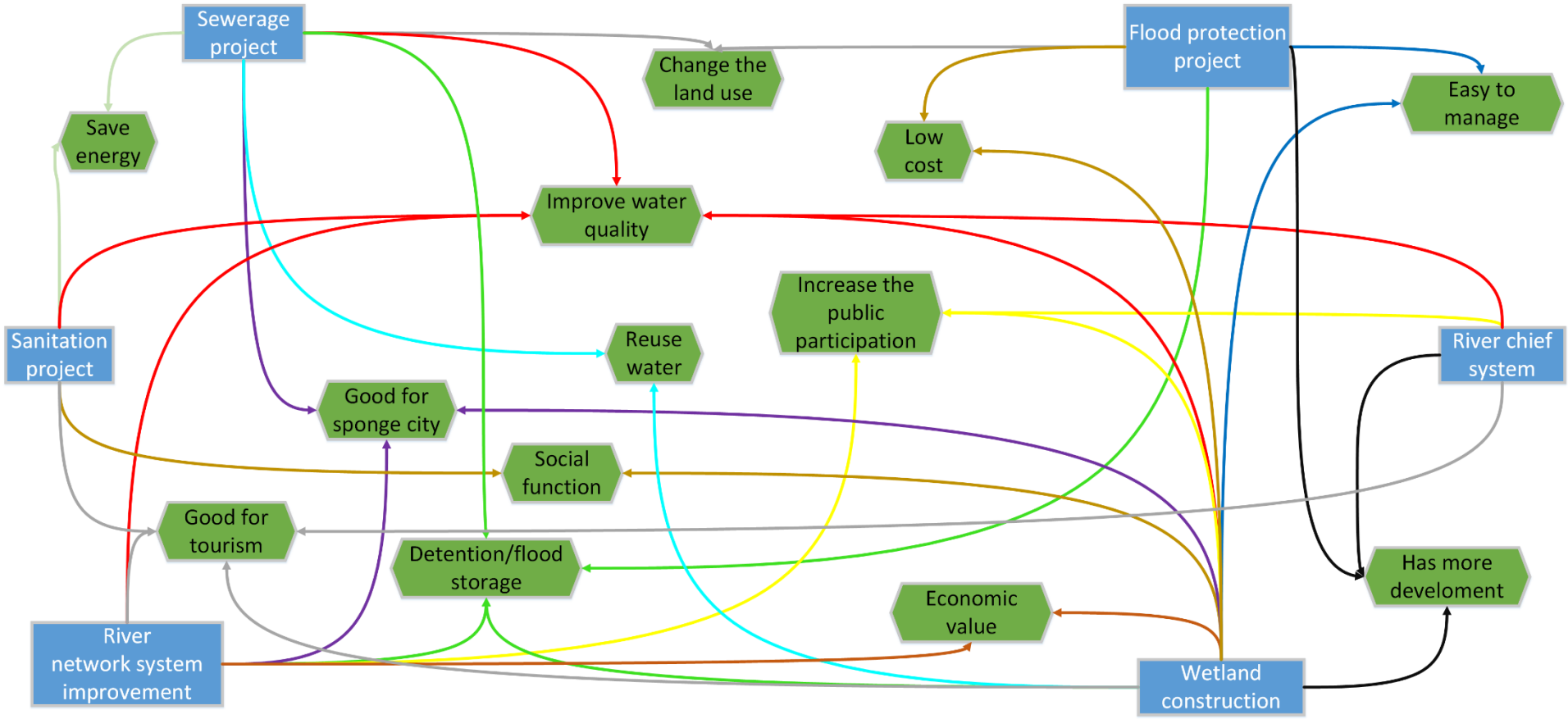


Figure 9 Synergy of actions in scenarios IV

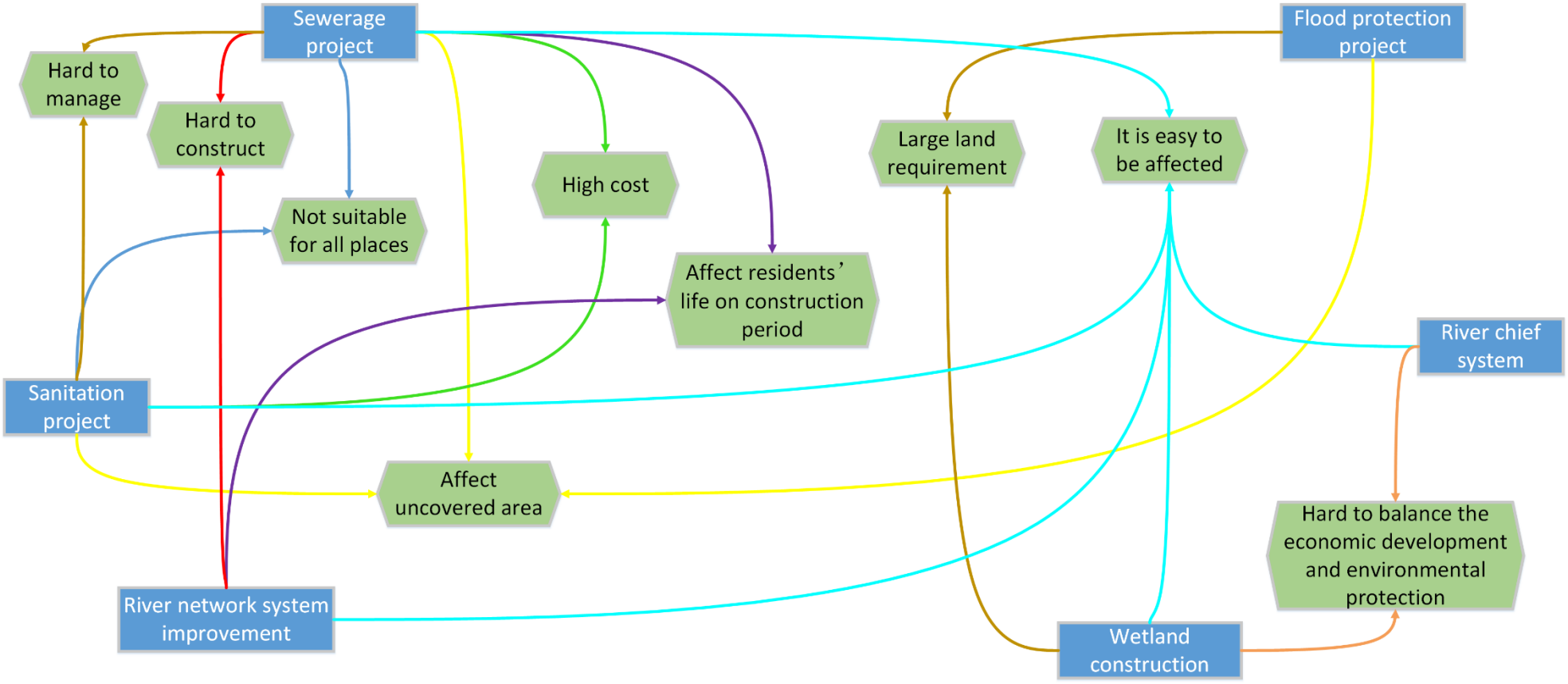


Figure 10 Bottlenecks of actions in scenario IV

Connections of all actions

Connection in base scenarios

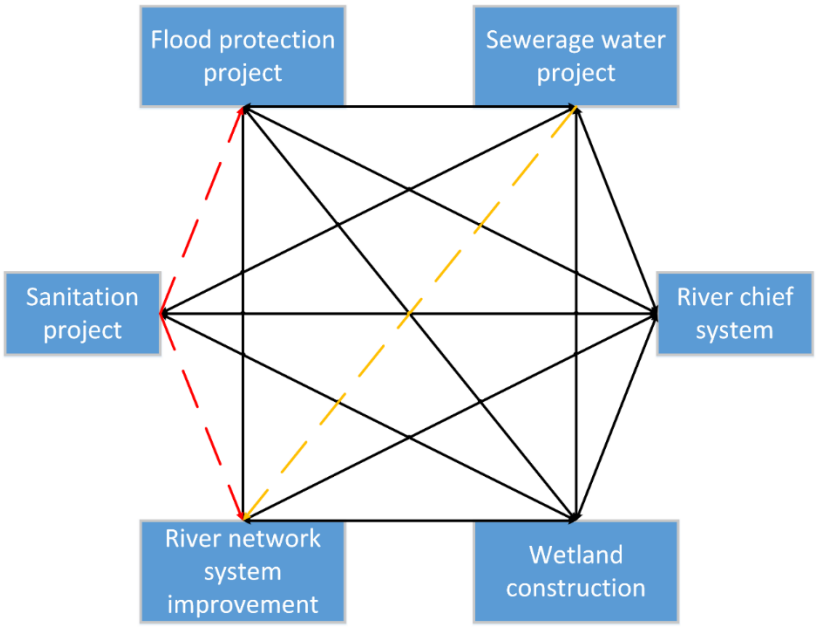


Figure 11 Mapping relationship of base scenario

The detailed DPSIR analysis for connection between each action in base scenario and how the indicator scored was arrived in each action is presented in Appendix C.

Table 17 The sum of final connection between all actions in base scenario

Base Scenario	Flood protection project	Sewerage project	Sanitation project	River chief system	River network system improvement	Wetland construction	Sum
Flood protection project		1	0	1	2	1	5
Sewerage water project	2		2	2	2	-1	7
Sanitation project	2	-1		1	2	2	6
River chief system	1	2	1		2	2	8
River network system improvement	2	0	0	2		1	5
Wetland construction	1	2	2	2	2		9

Connection in scenario Ⅰ

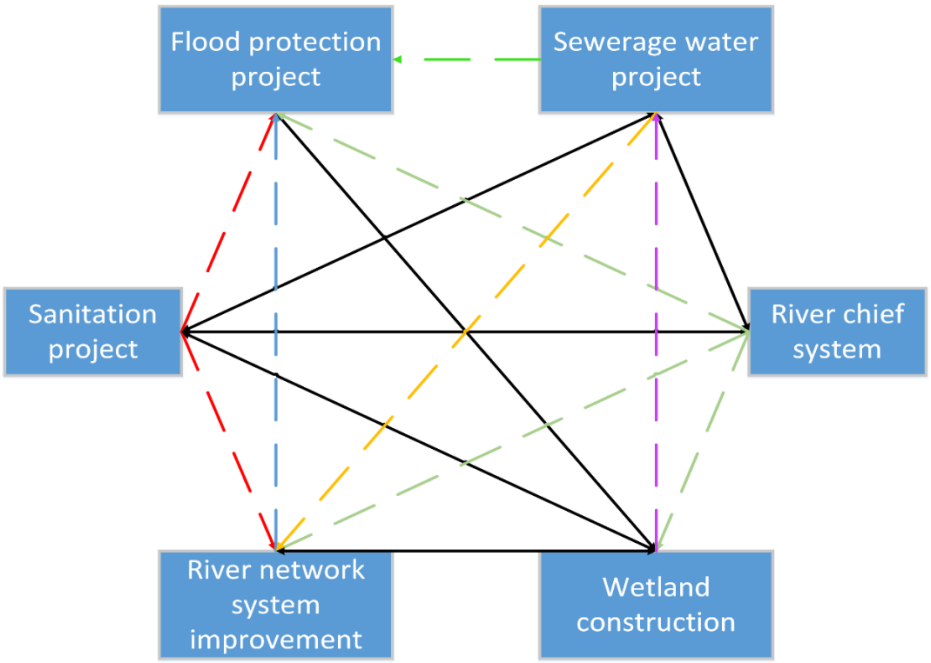


Figure 12 Mapping relationship of scenario I

The detailed DPSIR analysis for connection between each action in scenario Ⅰ and how the indicator scored was arrived at in each action is presented in Appendix C.

Table 18 The sum of final connection between all actions in scenario I

Base Scenario	**Flood protection project**	**Sewerage project**	**Sanitation project**	**River chief system**	**River network system improvement**	**Wetland construction**	**Sum**
Flood protection project	--	0	0	0	0	1	1
Sewerage water project	1	--	2	1	1	0	5
Sanitation project	1	-2	--	2	1	1	3
River chief system	1	2	2	-	2	2	9
River network system improvement	2	0	0	0	--	2	4
Wetland construction	2	2	2	0	2	--	8

Connection in scenario Ⅱ

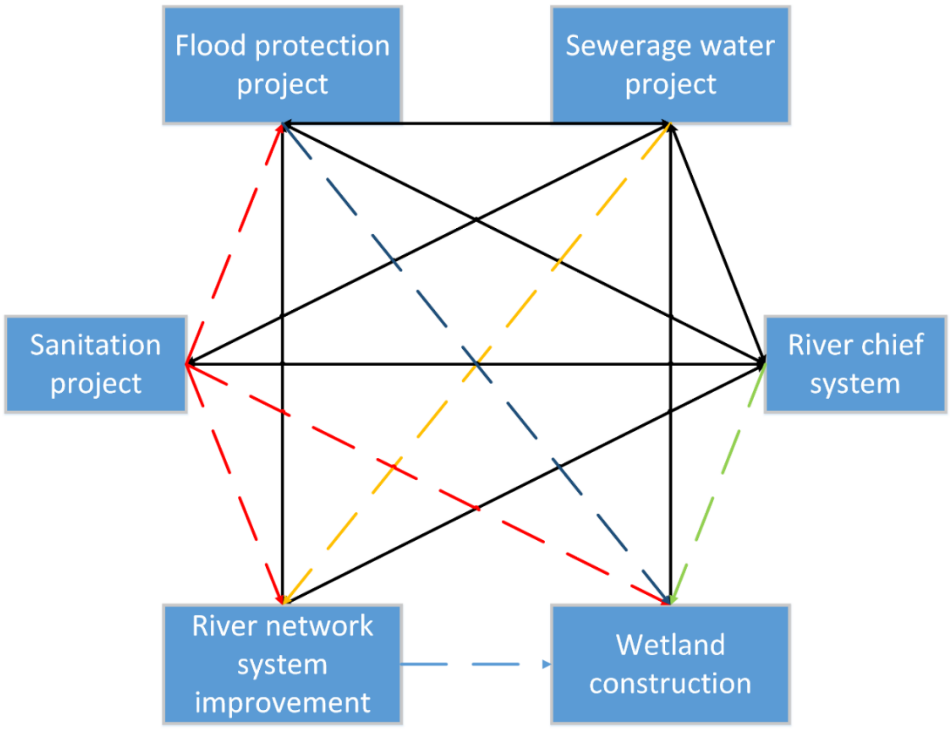


Figure 13 Mapping relationship of scenario Ⅱ

The detailed DPSIR analysis for connection between each action in scenario Ⅱ and how the indicator scored was arrived in each action is presented in Appendix C.

Table 19 The sum of final connection between all actions in scenario Ⅱ

Base Scenario	**Flood protection project**	**Sewerage project**	**Sanitation project**	**River chief system**	**River network system improvement**	**Wetland construction**	**Sum**
Flood protection project	--	1	0	1	2	1	5
Sewerage water project	2	-	2	2	2	-2	6
Sanitation project	1	-2	--	2	1	-2	0
River chief system	1	2	2	-	2	1	8
River network system improvement	2	0	0	2	--	-2	2
Wetland construction	0	-2	0	0	0	--	-2

Connection in Scenario Ⅲ

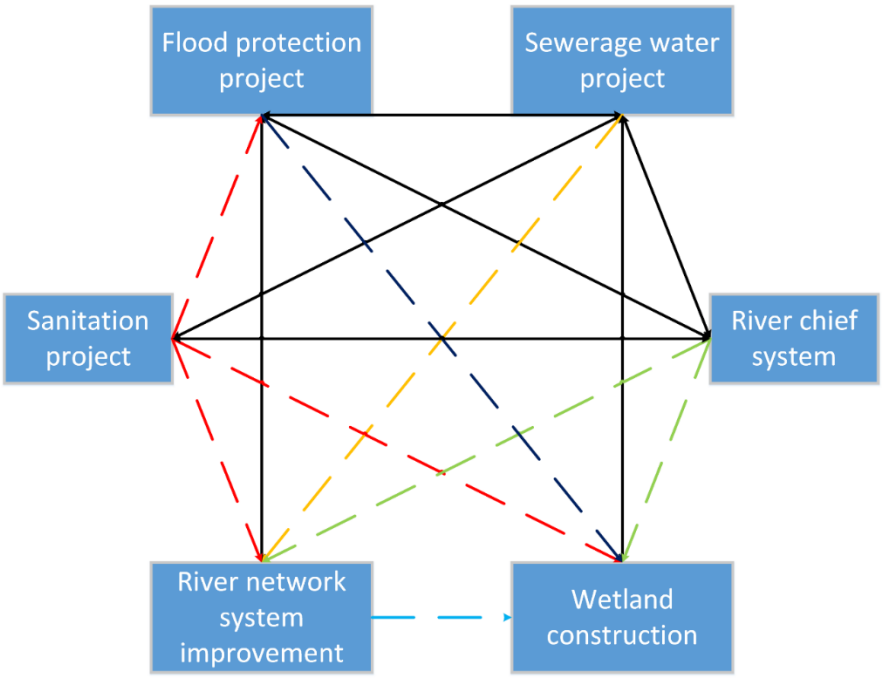


Figure 14 Mapping relationship of scenario Ⅲ

The detailed DPSIR analysis for connection between each action in scenario Ⅲ and how the indicator scored was arrived in each action is presented in Appendix C.

Table 20 The sum of final connection between all actions in scenario Ⅲ

Base Scenario	**Flood protection project**	**Sewerage project**	**Sanitation project**	**River chief system**	**River network system improvement**	**Wetland construction**	**Sum**
Flood protection project	--	1	0	1	2	1	5
Sewerage water project	1	--	1	2	2	-2	4
Sanitation project	2	0	--	1	2	2	7
River chief system	1	2	1	--	2	1	7
River network system improvement	2	0	0	2	--	-2	2
Wetland construction	0	-2	0	0	0	--	-2

Connection in Scenario Ⅳ

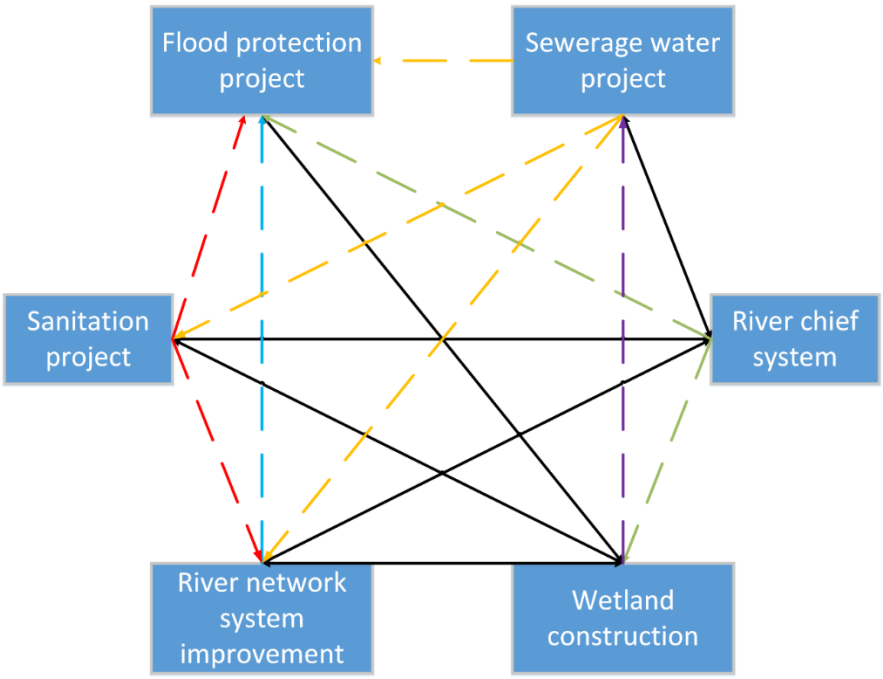


Figure 15 Mapping relationship of scenario Ⅳ

The detailed DPSIR analysis for connection between each action in scenario Ⅳ and how the indicator scored was arrived in each action is presented in Appendix C.

Table 21 The sum of final connection between all actions in scenario Ⅳ

Base Scenario	Flood protection project	Sewerage project	Sanitation project	River chief system	River network system improvement	Wetland construction	Sum
Flood protection project	--	0	0	0	0	1	1
Sewerage water project	1	--	1	1	1	0	4
Sanitation project	2	0	--	1	1	1	5
River chief system	1	2	1	--	2	2	8
River network system improvement	2	0	0	1	--	2	5
Wetland construction	2	2	2	0	2	--	8

References

China Daily. (2016). News Conference on the Guideline on Fully Implementing River Chief System(新闻办就《关于全面推行河长制的意见》有关情况举行发布会). Retrieved from http://www.gov.cn/xinwen/2016-12/12/content_5146921.htm

Guan, Y. (2015). 39 villages will finish the sewerage pipe system project in 2015(角直年内 39 村庄污水入管). *City business*. Retrieved from http://www.szwz.gov.cn/xwzx/004004/20150604/254864f6-2383-4e79-91cf-cb4f6913f476.html

Jia, H., Yang, C., Zhang, Y., & Chen, Y. (2013). Simulations of water quality improvement for urban river networks. *Tsinghua Univ(Sci&Tech), 53*(5), 665-672.

Li, C., & Meng, X. (2015). Path of Innovation of Water Environment Governance Model to Long-term Mechanism——Based on the "River Governor System". *Urban Environment & Urban Ecology*(6), 10.

Li, Y., Zhang, Y., & Jia, H. (2014). Water quality assessment for the ancient town of Luzhi. *Environmental Engineering, 32*(10), 61-65.

Liu, H., Chen, Y. D., Liu, T., & Lin, L. (2019). The River Chief System and River Pollution Control in China: A Case Study of Foshan. *Water, 11*(8), 1606. Retrieved from https://www.mdpi.com/2073-4441/11/8/1606

Lu, S. (2019). *Treatment technology and typical cases of black and smelly water body(黑臭水体治理技术及典型案例)* (Vol. 1): Chemical industry press co,Ltd.

Suzhou Luzhi Tourism Development co. LTD. (2011). The introduction of Songnan ecological agricultural area(淞南生态农业区). Retrieved from http://www.luzhitour.net/lyjd/chdjArticle-432.html

Suzhou Planning and Design Research Institute. (2016). *Implementation evaluation report of luzhi regulatory plan (2011-2030)(《苏州市角直镇总体规划（2011-2030)》实施评估报告)*.

Suzhou Shui Baxian Tourism Development co. LTD. (2016). The Introduction of Shuibaxian ecological cultural wetland park. Retrieved from http://www.szchny.cn/h-col-106.html

The Ecology and Environment Department of Jiangsu Province. (2019). Luzhi town, wuzhong district, suzhou people's congress focus on water pollution prevention and control(吴中区角直镇苏州首场镇级人大专题询问会聚焦水污染防治). Retrieved from http://hbt.jiangsu.gov.cn/art/2019/5/31/art_1565_8351713.html

The Housing and Urban-rural Development Department of Luzhi Town. (2019). Information on the bidding project of the rural sewage treatment project of luzhi Village in 2019(角直镇 2019 年农村生活污水治理工程). *Notice.* Retrieved from http://www.suzhou.gov.cn/szsrmzf/jsxmztbqk/201910/0BG77BYFFBGH83MCCSOKKTN2D5EMZXQF.shtml

The People's Government of Luzhi Town. (2018). The list of river chief in Luzhi Village(角直镇河长列表). Retrieved from http://wzsl.hilinker.com:8093/wx/wxgzh/RiverOwner/riverOwner.htm

The People's Government of Luzhi Town. (2019). The people's livelihood practical project of luzhi Village in 2019(角直镇 2019 年民生实事项目). Retrieved from http://www.szwz.gov.cn/frontPage/szwzq/xxgk/xxgkdetail.jspx?infoid=a347bfc7-3009-4323-aa3b-6b1d1a482cd6&categorynum=006003014001&deptcode=007006

The People's Government of Wuzhong District. (2017). *List of key projects for the optimization and improvement of ecological civilization construction in Wuzhong District (2017-2020)(吴中区生态文明建设优化提升行动计划（2017～2020 年）重点项目表)*. Suzhou, China Retrieved from http://www.szwz.gov.cn/frontPage/szwzq/xxgk/xxgkdetail.jspx?infoid=f35cb4ef-a2c1-4fa0-bc6e-8f0e9118f31f

The Planning Department of Suzhou. (2017). *Regulatory plan of luzhi Village, Suzhou (2011-2030) (revised in 2016)(苏州市角直镇总体规划（2011－2030 年）（2016 年修改）)*. Retrieved from http://www.zfxxgk.suzhou.gov.cn/sjjg/szsghj/201708/t20170801_892964.html

The State Council of China. (2016). *Opinions on the full implementation of the river chief system(中共中央办公厅 国务院办公厅印发《关于全面推行河长制的意见》)*. China: The Xinhua News Agency, Retrieved from http://www.gov.cn/xinwen/2016-12/11/content_5146628.htm

The Water Affairs Department of Suzhou. (2020). The municipal conference was held to promote the reform of river (lake) system and the construction of ecologically beautiful rivers and lakes(全

市深化河（湖）长制改革暨生态美丽河湖建设推进会召开). Retrieved from http://water.suzhou.gov.cn/slj/slyw/202001/fb22c79dac1f4a8683076889e82c9643.shtml

The Water Resource Department of Suzhou. (2019). An implemention report of improving the domestic wastewater in urban and rural area of Suzhou (市水务局市生态环境局市发展改革委关于印发《苏州市城乡生活污水处理提质增效行动实施方案》的通知). *Notice.* Retrieved from http://www.suzhou.gov.cn/szsrmzf/shuiwjdtxx/201910/7RO9GU3SHBBAPV40R2UYWBCRT0GAZ7I6.shtml

Xu, Z., Wu, J., & Xu, C. (2010). The application of artificial wetland in the river water quality improvement in Luzhi ancient village(角直水乡古镇河道水质改善中人工湿地的应用). *Jiangsu Water Resources*(1), 35-39.