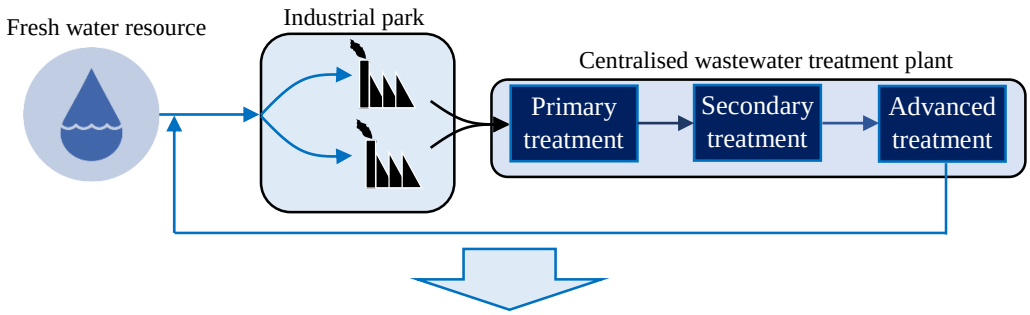
A novel framework for planning policy and responsible stakeholders in industrial wastewater reuse projects: a case study in Iran

Graphical Abstract



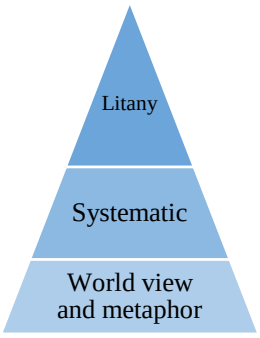
Comprehensive analysis for planning policy of advanced treatment units' development

Horizontal stage

Casual layered structure

Project's core phases

First phase → Second phase → ……. → Last phase



(1) Frequency analysis of responders' general perception based on PESTEL classification
(2) Frequency analysis of responders' general perception based on PESTEL classification
(3) Comparing differences between finding of (1) and (2)
(4) Analysing the distribution of visible problems based on project's lifespan

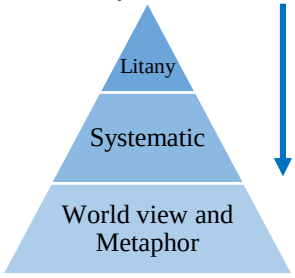
(1) Specifying the main responsible stakeholder supported with frequency analysis
(2) Comparing paradoxes between official role of stakeholders and documented roles

(1) Revealing the main adverse beliefs supported with frequency analysis
(2) Analysing the distribution of beliefs based on project's lifespan

Vertical stage

Revealing beliefs translated as problems in the litany layer as well as frequency analysis

Casual layered structure



Analysing responsible stakeholders and their role in occurrence of mentioned problems classified based on PEST method.

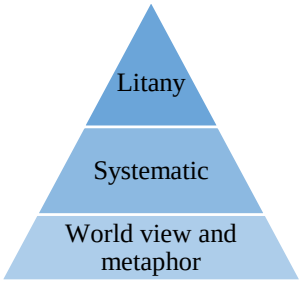
Specifying beliefs associated to responsible stakeholders

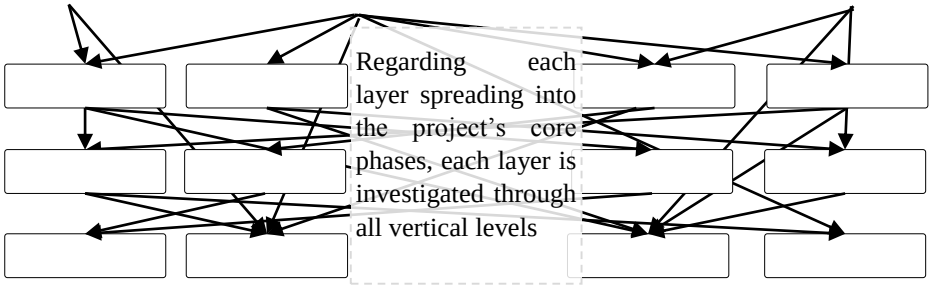
Deep mapping

Casual layered structure

Project's core phases

First phase → Second phase → ……. → Last phase





Regarding each layer spreading into the project's core phases, each layer is investigated through all vertical levels

A Novel Framework for Planning Policy and Responsible Stakeholders in Industrial Wastewater Reuse Projects: A Case Study in Iran

Short title: Planning Policy Framework in industrial wastewater reuse projects

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Abstract

Industrial wastewater recycling projects are mainly used for alleviation of both water scarcity and contamination of freshwater bodies. These projects mainly address major challenges related to technological, and economic aspects rather than stakeholders responsibility. Hence, little is known for the role of responsible stakeholders as a major part of planning policy, which requires recognition of their crucial role and integration into associated procedures. This paper presents a new decision support framework to identify responsible stakeholders and reveal the role of their motivations. The approach integrates qualitative and frequency analysis methods into a comprehensive framework to identify the problems over the project lifetime from visible to their roots and link them together with stakeholders through deep mapping. The planning policy framework is applied to a real-world case study of industrial parks in Iran. The results of the case study show that visible economic, social, and technological problems are caused by responsible stakeholders with no direct role in those projects. Additionally, deep mapping analysis shows various deep roots caused by the government and industry are linked to visible problems across all project phases that are related to the role of stakeholders, their behaviour, and deep beliefs.

Keywords: Causal layered analysis; Industrial wastewater treatment; Planning policy framework; Responsible stakeholders;

1 Introduction

Today, water resources in many parts of the world are under increasing pressure from irrigation-based food supply, increasing urban water demands and industrial growth especially in semi-arid and arid areas where water plays a vital role for their development, national economic growth, and environment (Cossio *et al.*, 2020). Among all water users, providing industrial water is crucial as lack of access to water resources may stop valuable economical productions. Furthermore, industrial wastewater is another major concern due to the contamination of untreated wastewater discharged into receiving water bodies (Piadeh *et al.*, 2014). Therefore, recycling industrial wastewater is a practical sustainable solution that can both provide accessible water and prevent contaminating freshwater bodies (Piadeh *et al.*, 2018a).

Nowadays, combining advanced treatment units (ATUs) with conventional treatment processes can result in less contamination in treated effluent (Naghedi *et al.*, 2020). Despite benefits of integrating these advanced technologies, stakeholders are sometimes reluctant to develop these units based on their own preferences and due to the complexity and uncertainty of reliability assessment in these ATUs and hence, overlook this scheme within the planning phases. As planning any wastewater reuse scheme needs active engagement of relevant stakeholders, the lack of appropriate involvement or having negative views on decision making, design, construction and operation phases may lead to a failure of these schemes over a long-term period (Salgot and Folch, 2018).

Several studies investigated the stakeholders' behaviour and their motives for being against the ATU development. For example, Ba-Alawi *et al.* (2020) analysed man-made incidents and faults in the ATU equipment. Piadeh *et al.*, (2018b) also analysed consultants' faults for design and contractors' failure in construction. For studies analysing environmental and economic risks, stakeholders were considered only as investees or investors (Hernández-Chover *et al.*, 2018). Some studies limited the role of stakeholders in end-users views to support recycled wastewater or willingness to pay tariffs (Dalhat Mu'azu *et al.*, 2020). Additionally, some studies only analysed the role of policymakers in strategic decisions such as increasing tariffs or environmental regulations to motivate ATU developments (Buzuku *et al.*, 2015). Some studies also analysed the role of stakeholders as public acceptance, number of stakeholders participating in the

development, number of new jobs created and health risk in sustainability assessment criteria (Cossio *et al.*, 2020). In relevant studies including abovementioned ones, the role of vital stakeholders was almost neglected and consequently, the main intention of interruption due to the stakeholders involvement were not studied properly. Hence, the main objective of this paper is to develop a new framework to analyse the role of relevant stakeholders and their motives for reusing treated industrial wastewater, which is raised from the following three research questions (RQs): (RQ1) which associated responsible stakeholders influence ATU projects and how they can be identified? (RQ2) what type of visible problems are caused by responsible stakeholders and how these problems can be distributed among the different processes of ATU projects? (RQ3) if there is any connection between deep beliefs of responsible stakeholders and associated problems?

To address these questions, the framework in this study aims to analyse stakeholders, futurology techniques and deep mapping as qualitative analysis to (1) identify relevant stakeholders and their role in different phases in an ATU project, (2) determine responsible stakeholders for relevant system failure and identify their motivations, and (3) map all levels of problems across the different phases of the project. Furthermore, frequency analysis is used to provide quantitative analysis. A comprehensive analysis developed in this study compares all identified problems, associated stakeholders. Additionally, the framework provides a vertical comparison between the connection of problems with responsible stakeholders and links all these analyses together through deep mapping. The next section describes the proposed methodology followed by its demonstration to the real-world case study. The results are then discussed, and key findings are finally summarised.

2 Methods

The proposed framework of this study as shown in Figure 1 contains three main steps to assess the role of responsible stakeholders in industrial wastewater reuse projects. Step 1 applies a method to identify the project phases over the project lifetime, key stakeholders, and their distribution over each phase of ATU projects. Step two entails identifying visible problems at various layers, connecting these problems to responsible stakeholders and investigation of their deep beliefs. Step 3 finally demonstrates a

comprehensive analysis including deep mapping for all layers and stakeholders over the lifetime of ATU projects. Note that the proposed methodology is generic that can be applied to similar ATU projects all over the world. Having said this, the proposed method is demonstrated in section 2.4 by its application to a real case study of industrial wastewater reuse projects in Iran.

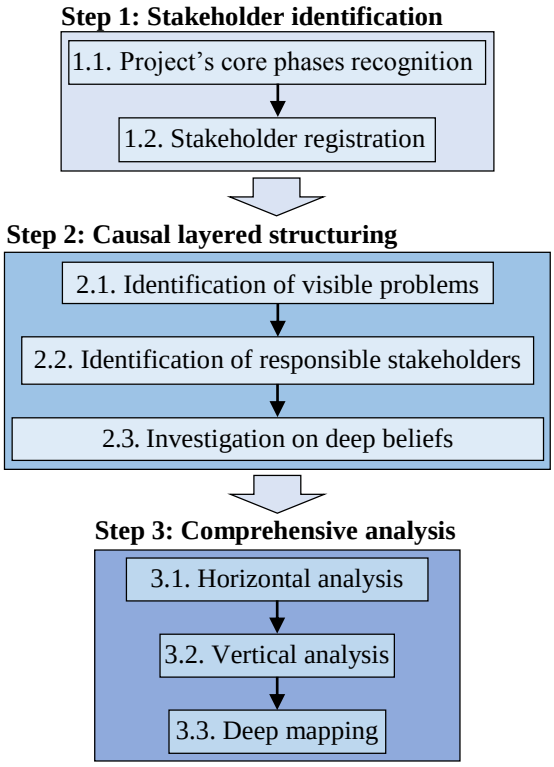


Figure 1. Proposed framework in this study

2.1 Step 1: Stakeholder identification

The aim of this step is to specify the distribution of stakeholders across different project phases as the input of next steps and form a map to show how stakeholders with their roles are connected to core phases over the project lifetime. This needs different phases are clarified over the project lifetime (in section 2.1.1) and then the stakeholders are registered for each phase (in section 2.1.2).

2.1.1 Recognition of the project phases

Core phases defined in a project based on the primary goals can be recommended in four parts of "planning", "design", "construction", and "operation" (PMI, 2017). Core phases are first compiled from official documents such as project charts, procurement documents, organisational process assets, regulation and laws or internal instructions (Lalmi *et al*., 2021).

2.1.2 Types of stakeholders

This step entails identifying people, groups, experts and organisations that could impact or be affected by a decision, activity, or outcome of the project (Alcon *et al.*, 2014). Stakeholders here are classified as primary and secondary categories based on the stakeholder theory widely used in the literature (Gherghel *et al.*, 2020). The primary stakeholders are identified as those in the institutional positions with relevant roles dedicated across core phases based on official documents or administrative procedures. The secondary stakeholders with their roles can also be identified by the judgment of experts, i.e. primary stakeholders (Bendtsen *et al.*, 2021).

2.2 Step 2: Causal layered analysis

This step aims to list all the problems considered as obstruction of ATU developments through identifying a range of visible problems to their deep roots i.e. the causal layered analysis (CLA) method. Figure 2 shows the hierarchy of the CLA to clarify problems widely applied to a range of topics in the projects and find solutions influencing possible future scenarios positively (Miremadi, 2020). Three main layers of the CLA include (1) the visible problem layer (also called litany layer) representing the conventional perception of problems that seems obvious and visible; (2) the responsible stakeholders layer (e.g., systemic layer) representing social explanations of events, issues and problems documented in the visible problem layer. This layer also explores the roles of stakeholders responsible for occurrence of problems; (3) the deep belief layer (the worldview and metaphor layers) seeking values, assumptions, discourses, ideas, and more importantly deep beliefs of responsible stakeholders that cause visible problems but not necessarily consciously happen.

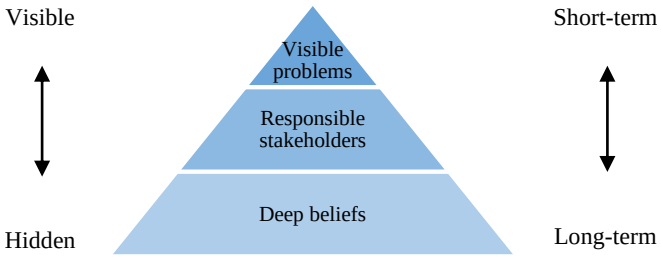


Figure 2. Structure of causal layered analysis defined to classify problems, stakeholders and their deep beliefs

2.2.1 Identification of visible problems

The visible problem layer is based on the problems identified through questionnaires/interviews by selected responders and strengthened by evidences from the project documents or site visits. All identified stakeholders in step 1 should introduce a representative person called a responder to participate an interview. The major problems can be classified under more sub-classes for better analysis. This classification is based on how decision-makers and experts are familiar to. However, the PEST framework is recommended here due to its ability to the holistic illustration of the current situations (Thakur, 2021). In this framework, all problems are divided into the 4 categories: (1) political problems at national, international and regional scales or regulations, which impact on developing ATUs negatively, (2) economic problems e.g. lack of financial mobilising, lack of allocated budget, budget cuts or requiring extra costs, (3) social problems e.g. lack of proper management, individual wrong behaviour or managers' personal preferences, (4) technical problems, particularly technological gap, maintenance issues and accessibility to desired equipment (Naghedi *et al.*, 2020).

The responders first need to raise the most challenging problem representing the main influential factor of improper ATU's development. Each responder is then asked to scrutinise the challenges in detail via (1) describing the problem, (2) classifying the type of the problem based on PEST classification, (3) specifying the occurrence of the problem among all of the core phases of the project (step 1.1), and (4) classifying all identified stakeholders under primary and secondary stakeholders (step 1.2). All identified problems are then clustered based on their similarities and the visible problem layer is finally formed.

2.2.2 Identification of responsible stakeholders

This layer identifies responsible stakeholders and their role in the project components over the project lifetime. For this purpose, each identified visible problem is assigned to a focus group with members from all relevant stakeholders. These focus groups describe relevant visible problems and their associated responsible stakeholders in which all responders are agreed through a qualitative Delphi technique (Cheng *et al.*, 2019). The output of this step is "specified responsible stakeholders" agreed by all responders.

2.2.3 Investigation on deep beliefs

Deep belief in here refers to the strong belief of stakeholders as the best way to manage or run the project. This can also reflect the understanding, knowledge, and experience of stakeholders for dealing with the project within all phases of the project including planning, design, construction and operation. Extracting deep beliefs is a challenging process mainly because it is subjective and discussed in the social sciences (Farrow, 2019). Here, responsible stakeholders are interviewed individually to find out their views and deep beliefs which consciously or unconsciously prevent developing the ATUs projects. Furthermore, it is recommended that specialists in various fields such as psychology, sociology, economy, management, philosophy, theology, political science, and history assist the interview to understand the deep beliefs of responsible stakeholders.

2.3 Step 3: Comprehensive Analysis

Step 3 is the comprehensive analysis through the LCA based on both quantitative and qualitative analyses by using horizontal & vertical analysis, and deep mapping. The horizontal analysis can provide details of each layer throughout the project lifetime (core phases) to realise the distribution of the problems, associated responsible stakeholders and their beliefs (Figure 3a). Hence, the horizontal analysis aims to (1) provide frequency analysis of visible problems, associated responsible stakeholders, and their deep beliefs, and (2) demonstrate the distribution of findings throughout the core phases. Regardless of the ATU project lifetime, interactions between different layers are evaluated by vertical analysis (Figure 3b). These interactions link (1) the visible problems level to the responsible stakeholder layer, (2) the responsible stakeholder layer to the deep beliefs layer, and (3) the visible problems layer to the deep beliefs layer. Deep mapping shows how layers and divergent phases of the ATU projects are linked together and demonstrates how visible problems can be interconnected with responsible stakeholders and sequentially any hidden beliefs behind them.

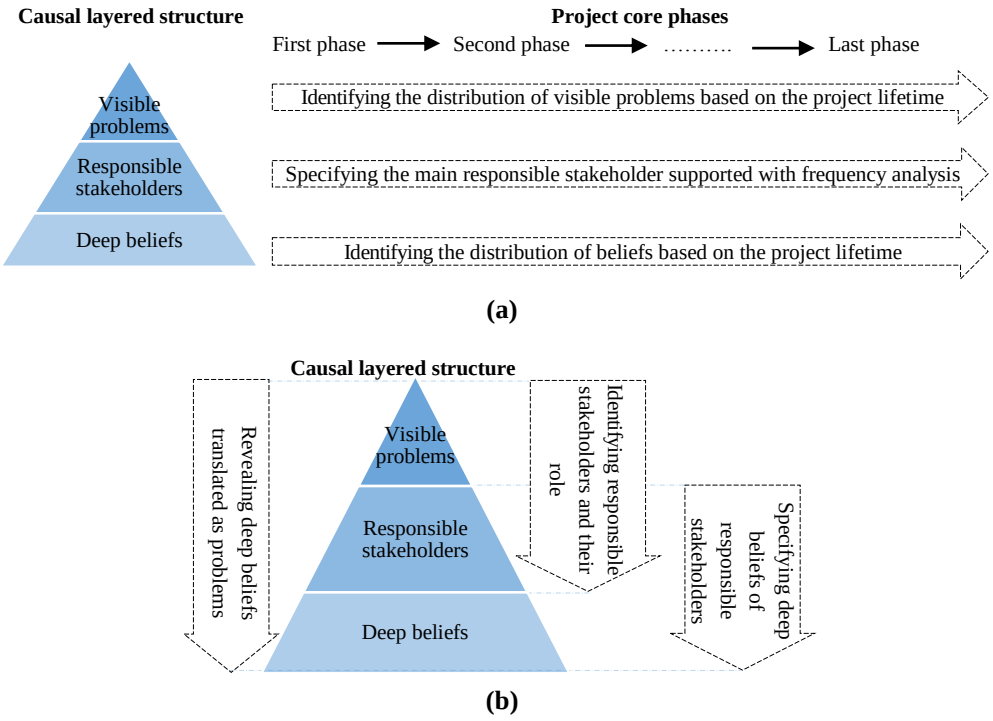
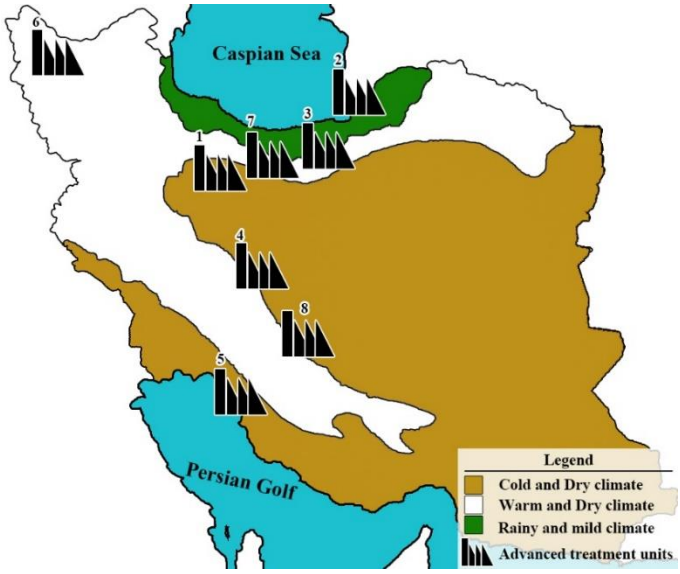


Figure 3. Schematic representation of comprehensive analysis in (a) horizontal stage, (b) vertical stage

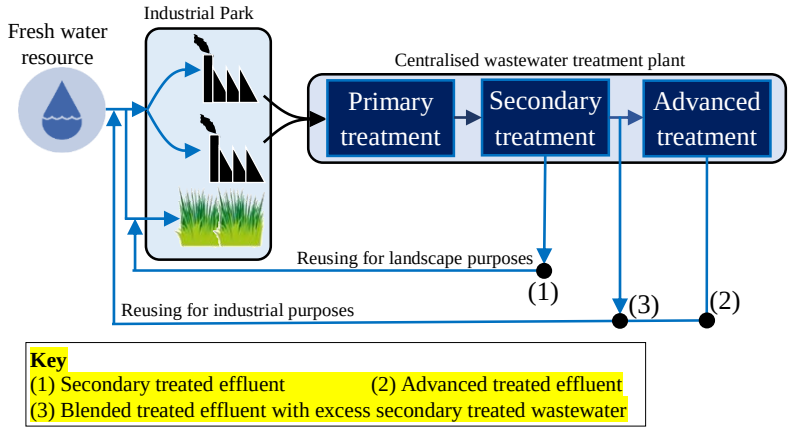
2.4 Case study

The above methodology is here demonstrated through its application to real-world case study of industrial wastewater reuse projects located in industrial parks in Iran. The parks are mainly based in semi-aired regions suffering from a lack of industrial water access (Naghedi *et al.*, 2020). Despite using only 6% of the total water demand, there are major challenges to supply this demand in these regions. Besides, untreated industrial wastewater can negatively affect both human health and the environment due to highly toxic contaminants (ISIPO, 2021). Therefore, industrial wastewater reuse has been highly recommended over the last decades as a practical sustainable solution to recover treated wastewater as a new water resource and minimise discharging contamination into freshwater bodies (ISIPO, 2021). While the initial plan was to treat wastewater by secondary processes and reuse it for landscape consumption (for 62 out of 187 industrial estates), the updated plan was to expand the treatment by using advanced treatment units for reusing treated wastewater for industrial purposes such as supplying cooling towers (Figure 4). Despite the above strategic plan in Iran, only 8 ATUs, accounted for only about 4% of the total treated wastewater, is currently operating with the updated plan as shown in Figure 4a (ISIPO, 2021). This can be mainly due to facing many problems posed all over the project lifetime. These problems are analysed in the following within three steps outlined in the above methodology.



Code	Name	Q (m^3/day)	Design year	Operation year
1	Shokuhiye	300	2008	2010
2	Aq-qala	170	2008	2010
3	Semnan	350	2008	2011
4	Murche khurt	1000	2010	2012
5	Bushehr 2	300	2010	2012
6	Shahid Salimi	600	2012	2015
7	Abbas-abad	1000	2016	2020
8	Razi	1000	2016	2020

(a)



(b)

Figure 4. Industrial wastewater reuse projects in the case study (a) layout of the projects with key features, (b) schematic flow diagram of the water cycle and reuse in these projects

3 Results and discussion

The analysis started off with reviewing official documents such as procurement documents of ATU construction and operation, consultancy, and plant monthly reports of ATUs operation to identify the core phases of the ATU plants and associated stakeholders as illustrated in Figure 5 with more details in part A and Figure S1 in the online supplementary material. Further to contacting the stakeholders, 78 responders agreed to participate in the interview listed in Table S1 in the online supplementary material. Each responder first fills out a questionnaire and then participated in a meeting held for focus groups based on the details outlined in the methodology. The results of causal layered structure are reported in Table S2 in

the online supplementary material. The comprehensive analysis including horizontal, vertical, and deep mapping are discussed below.

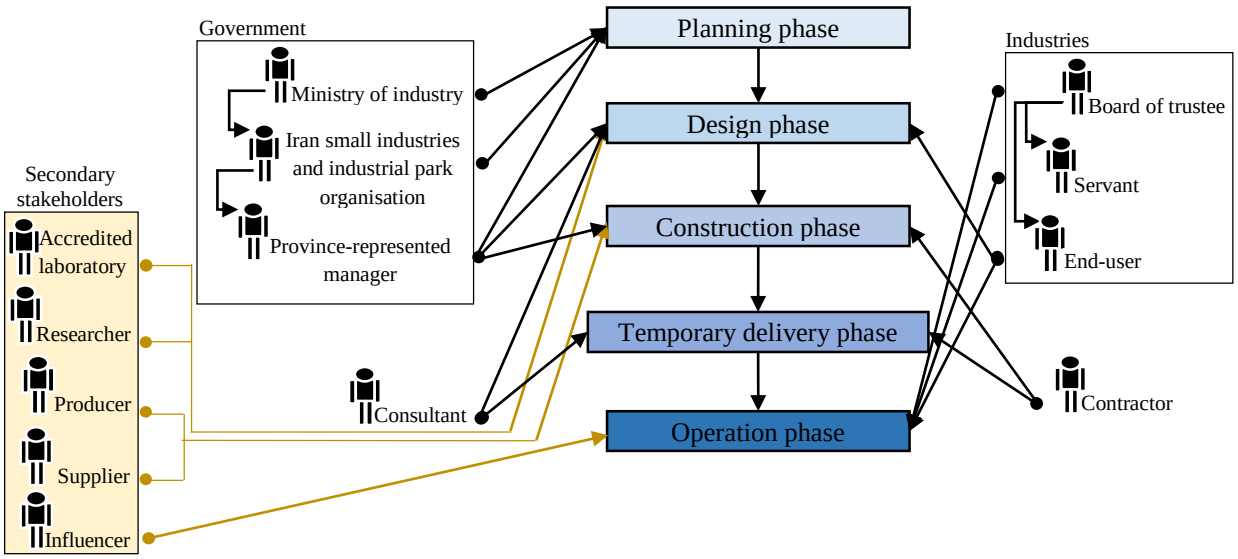


Figure 5. Identified stakeholders and distribution of their role in the core phases of industrial wastewater reuse projects

3.1 Visible problems

Table 1 shows the result of the PESTEL method by using the input from the responders to identify the visible problems. Out of the six categories in the PESTEL method, the responses for number of general perceptions, total identified problems, and number of total visible problems are classified under four categories including political, economic, social and technical components. Although responders initially stated in the questionnaires that economic component is the major issue preventing the development of ATU systems for treating industrial wastewater, the major issue was then moved to the social component followed by technical component in practice, when responders analysed all problems in detail within the focus group meetings. This may show that responders tent to see all the problems in the shape of economic, especially because lack of budget resources are always proposed by the government. Furthermore, this comparison shows that the main nature of problems hindering the proper development of ATU systems can vary from economic to social aspects when they are analysed in detail compared to when they are only based on general perceptions. Therefore, it seems that scrutiny of the project problems can lead to clarify the real source of the problems at the litany layer.

Table 1. Responses and classification of problems based on the PESTEL method

PESTEL components	number of general perceptions	number of mentioned problems	Total number of visible problems
Political	3	0	0
Economical	**35**	98	3
Social	23	**338**	**11**
Technical	17	**310**	**10**
Environmental	0	0	0
Legal	0	0	0
Total	78	746	24

Figure 6 shows the results of the horizontal analysis (i.e., through the core phases of the projects) for all visible problems. The results imply that the distribution of the visible problems is inconsistent at different phases. More specifically, majority of more visible problems are related to design, construction, and operation phases compared to planning and temporary delivery. Besides, while a large proportion of problems in design and operation phases are related to social problems, construction phase predominantly has technical issues. However, economic problems seem to exist as a minor issue in planning, construction, and operation phases.

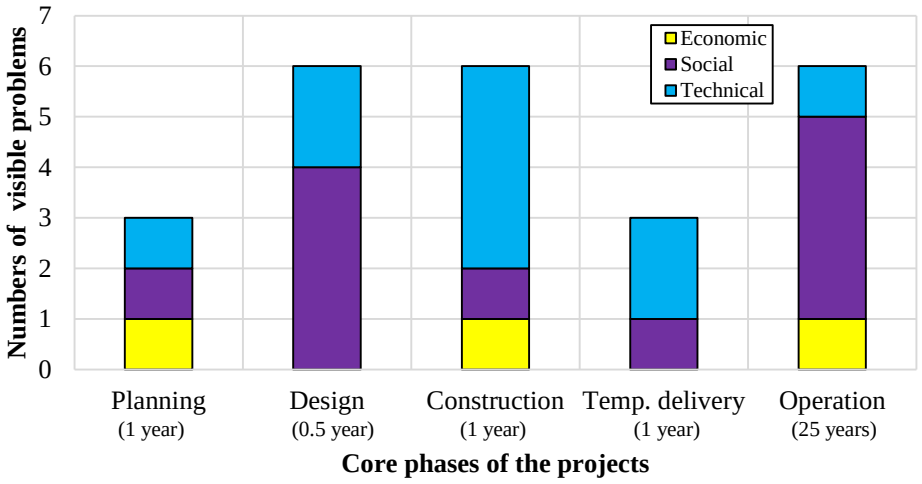


Figure 6. Numbers and distribution of identified visible problems

On the other hand, although the same number of problems are reported for design, construction, and operation phases, it seems that the design phase is more vulnerable and plays a vital role in delaying the ATU projects especially because the six mentioned visible problems occur in only six months whereas the duration of construction and operation phases are a year and up to 25 years, respectively. Therefore, social problems in the design phase seem to be the most critical ones. More details of these problems reported by the focus groups include (1) qualified consultants are not used or there is lack of qualified one or those

hired are unable to design the plant properly, (2) lack of international consultants in the projects that are qualified for the design, (3) lack of access or use of recent practical national researches or neglecting them, and (4) lack of hiring accredited private laboratories to enhance the results and hence declining the errors, and instead using limited parameters with a large uncertainty for ATUs design. In other words, identified social problems in this part are mainly related to avoiding or neglecting qualified or accredited stakeholders that can provide more accurate design plans.

3.2 Responsible stakeholders

Figure 7 shows the results of the identified stakeholders and their distribution throughout the lifetime of the projects. As can be seen, the government is responsible for 40% of the total number of identified stakeholders causing the visible problems. Furthermore, Unlike the results of stakeholder registration obtained in step 1 (stakeholder identification), responders reported that the government, industries, and politicians are responsible for some problems in which the government has no official role (blue dots in Figure 7). This finding is a crucially important that reflects problems which cannot be addressed through common existing channels relying heavily on official roles or official procedures. In other words, while normal and contractual procedures such as claiming processes or official meetings can be sought when problems appear between different stakeholders, these tools cannot resolve the outstanding problems because responsible stakeholders have no official roles. Thus, these viral points i.e., where stakeholders are responsible for visible problems but have no official role, should be carefully extracted to find future innovative solutions such as designing win-win scenarios for the cases where all responsible stakeholders obtain the partial desired benefits.

Besides, the results show that the stakeholders are responsible mostly in the construction and operation phases, which means problems in these phases are carried out by more diverse stakeholders. This is crucial as when more responsible stakeholders are engaged in one phase, finding a solution needs more agreements upon all stakeholders, which result in a more complicated situation with harder conflict resolution. Therefore, the construction phase involving six responsible stakeholders and contains 27% of total stakeholders, is recognised as a critical core phase of the ATU projects. However, this may not be

compatible with general perception of stakeholders about the most critical core phase, in which design operation phase is introduced by initial perception (See Table S3 in the online supplementary material). This can show that how deep analysis of ATU's projects through scrutinising responsible stakeholders can reveal actual role of these stakeholders and clarify impact of their role in finding critical core phase of ATU projects.

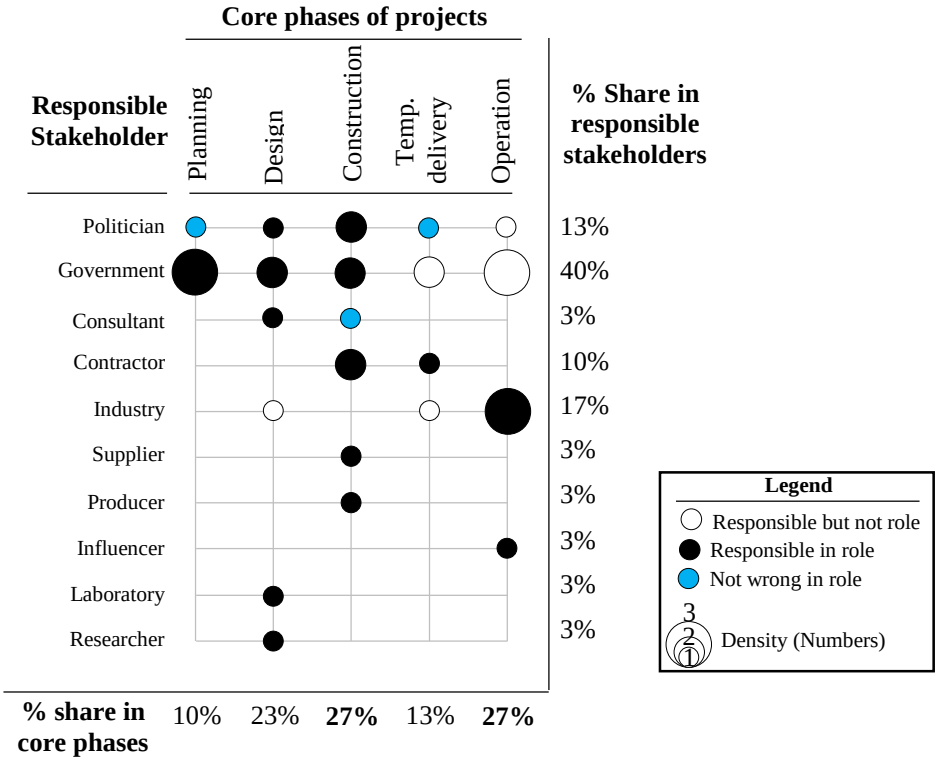


Figure 7. Distribution of stakeholders within the core phases of the projects

3.3 Deep beliefs

Based on detailed interview with responsible stakeholders, ten main reasons were extracted as "deep beliefs" of responsible stakeholders that cause visible problems (Table 2). Figure 8 illustrates the distribution of these beliefs throughout the core phases. As can be seen, presence of "no long-term planning" belief, reflecting a lack of attention to/analysis of possible future scenarios, consequence of wrong decisions or selections, is spread all over the project core phases and accounted for 23% of total identified deep beliefs. Additionally, four other beliefs (i.e. "no systemic planning", "individualism criteria", "lack of trust", and "adherence to anti-value") are in place for 4 out of 5 phases. Therefore, a large share and distribution of these beliefs for developing the ATU projects can be translated into complex situations and hence

obstacle with numerous visible problems. Furthermore, the design phase stands alone for 35% of total identified deep beliefs closely followed by the construction and operation phases. Besides, almost all revealed beliefs occur in the design phase which are more severe than other phases.

Table 2. Identified deep beliefs for the case study

Code	Title	Definition
B1	No systemic approach	No clear understanding about nature of problems, relationships and interactions between the components and no analysis to obtain a reasonable solution.
B2	No long-term planning	Lack of attention to/ analysis of possible future scenarios, consequence of making wrong decisions or selections.
B3	No flexibility with criticism	No capacity for critical thinking and accepting reasonable recommendations and no belief in meritocracy based on skills and abilities.
B4	Individualism criteria	Focus on individual achievements instead on quality-oriented or plan-oriented criteria to select staff with the highest ranked occupational efficiency
B5	Sense of being wiser	Superior feeling and top-down / hierarchy vision because of believing in having higher educational level or position in comparison to knowledge or experience
B6	Lack of trust	Existing long history of penalising and wrong activities that ruin trusts
B7	Westernisation	Believing in foreign activities, equipment, or any related issues without any reasonable evidence
B8	Pan-iranism	Superiority thinking towards Iranian (national) experts without any reasonable evidence
B9	Adherence to anti-value	A tendency to legal abuse and cheat as a value, having a system based on relationships, prior personal interests over public ones because cheating is a cultural value and is equal to cleverness
B10	Deep gaps	Deep gap in cultural, social, and characteristic between stakeholders

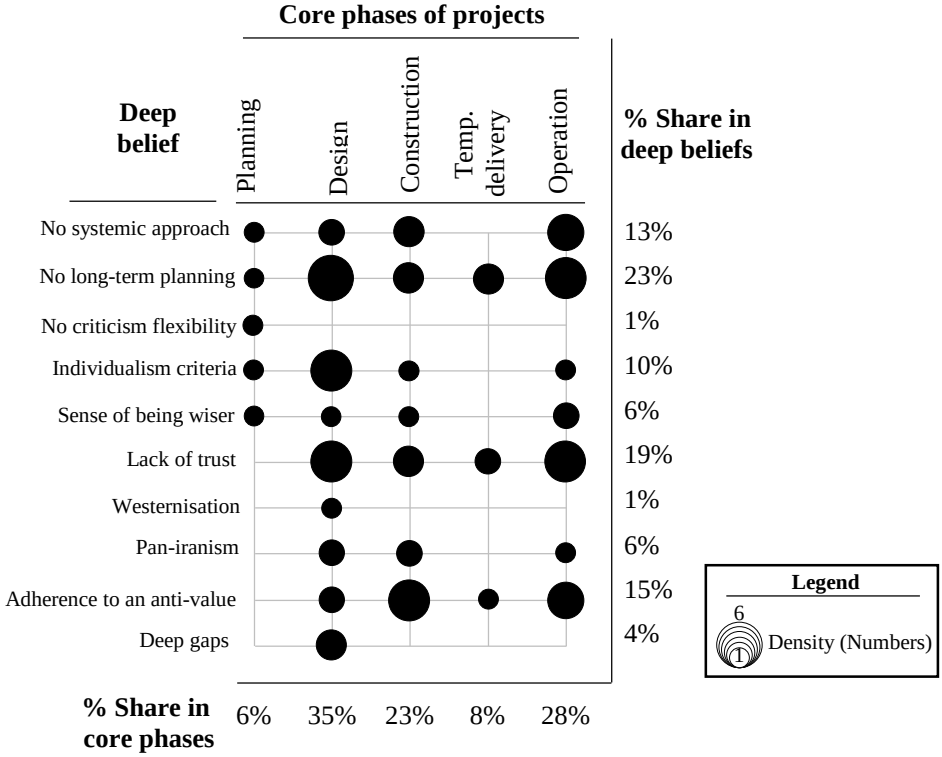


Figure 8. Distribution of deep beliefs within the core phases of the projects

3.4 Comparison of different layers

While the visible problems are usually easier to identify in comparison to deeper layer such as responsible stakeholders, correlation between these layers shows connections between frequency or type of visible problems and different stakeholders, as illustrated in Figure 9a. Out of all responsible stakeholders, only the government and industry are responsible for all three types of visible problems (i.e., economic, social, and technical) while politicians and contractors are reported mainly for social and technical problems. Other stakeholders are recognised as responsible for only one type of visible problems. This shows that while a few stakeholders may cause diverse forms of visible problems for the process of ATU development, some others can be easily identified for one specific type of the visible problems. For example, consultants, influencers, laboratories, and researchers are categorised as responsible stakeholders causing social problems only. While each type of visible problems needs a unique solution, economic problems can be resolved by the same method applied for many responsible stakeholders. However, records for the number of visible problems show the government is responsible for several problems compared to other stakeholders. This implies that until these problems are not addressed, ATU development is unlikely to be on the right track.

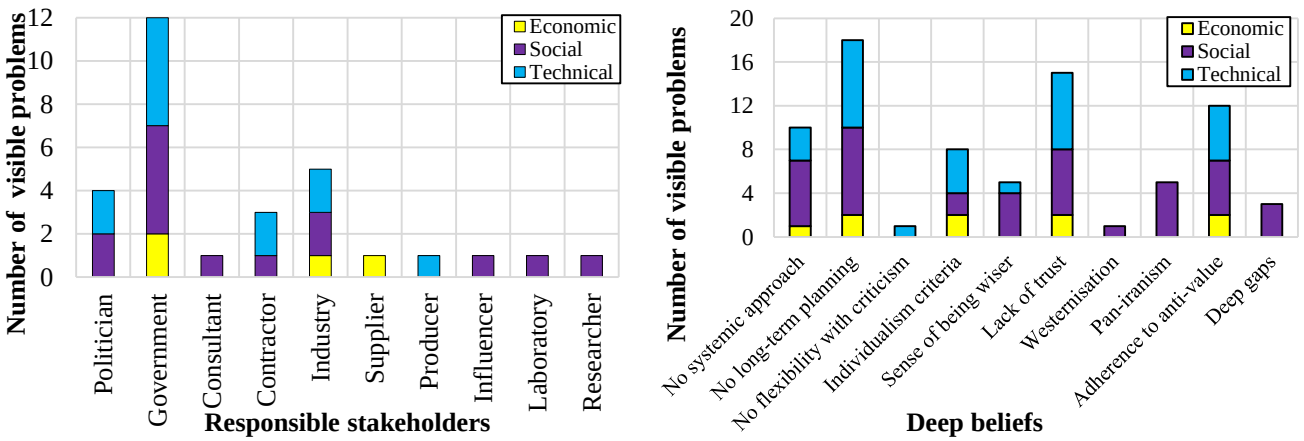


Figure 9. Distribution of identified visible problems based on (a) responsible stakeholders, (b) deep beliefs

The key massage of comparison between visible problems and deep beliefs of stakeholders is to understand how to translate beliefs into visible problems. This is crucial as these beliefs are usually hidden behind the visible problems and original and true instincts are hard to be recognised. For example, while running ATU projects need at least 3 years (Figure 5), managers prefer to agree with developing projects with the shorter

required time to account these projects operational as an outcome of their management period. Consequently, insufficient budget is always reflected as the main issue unless associated deep beliefs are really understood well.

Figure 9b shows the distribution of identified deep beliefs in the forms of economic, social, and technical visible problems. As can be seen, 4 out of 10 identified deep beliefs are reported in all three forms of visible problems likely due to the complexity of their situation that may not be understandable within one single form. These beliefs include "lack of systematic and long-term planning", "lack of trust between different stakeholders" and "adherence to anti-value action". This deteriorates when the frequency of reported visible problems for these deep beliefs increase compared to others. Consequently, this situation clearly shows how deeper layers can change the understanding of visible problems with respect to complicated deep beliefs that may be difficult to resolve.

3.5 Deep mapping

Deep mapping aims to connect all vertical layers, i.e., visible problems, responsible stakeholders, and deep beliefs, to horizontal approaches, i.e., core phases of the ATU projects. Figure S2 in the online supplementary material illustrates full details of the complex network but part of it for the government is shown in Figure 10. These figures obviously implies that analysis of the ATU development can be an arduous task to understand when only visible problems are in place. Complex network between visible problems, responsible stakeholders, and their beliefs represents complicated transforms between visible problems such as economic or technical to deeper and other strategic concepts including lack of systemic approach and long-term planning. More specifically, the frequency of lines in the earlier phases, drawn in Figure 10, show the role of the government as main responsible stakeholders. However, their beliefs and consequent actions cannot be translated easily into uniform type such as just economic or social form and require further deep analysis. While some social visible problems can be connected to deep beliefs, finding relationship between deep beliefs and technical problems, for instance, seems to be impossible. Hence, this mapping can reveal the complexity level of problems in the ATU development and provide at least a

network that connects different layers to each other which can be used for further long-term planning and management.

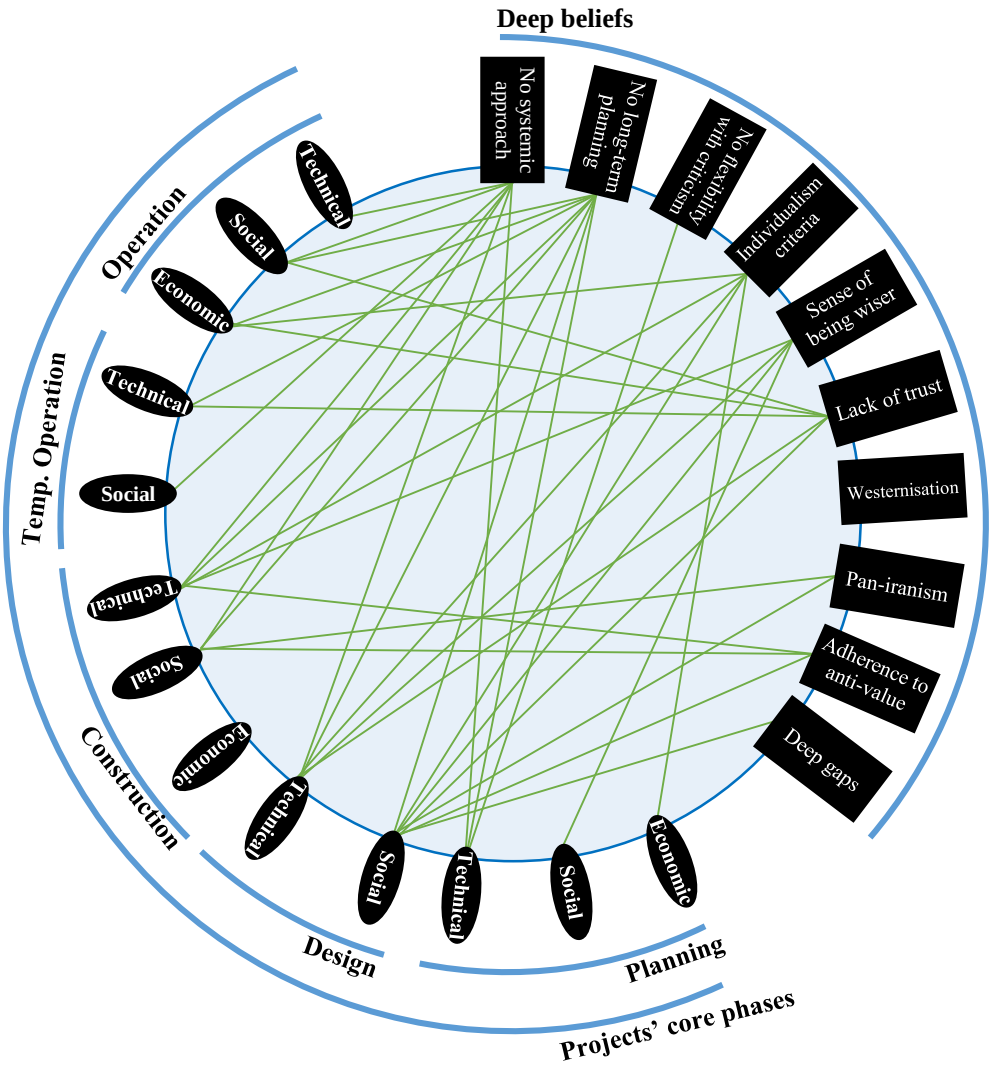


Figure 10. Deep network mapping between identified visible problems for the government, and their beliefs through the core phases of ATU projects

3.6. Limitations

The present study had the following limitations: (1) it highly relied on expert judgments, especially for finding visible problems. This is mainly because the case study suffers from proper historical experimental and numerical data, (2) while all stakeholders involved in the questionnaires were already verified, the number of experts and specialists in the industrial wastewater recycling projects of the case study are limited because these projects were developed recently, (3) while the study aimed to reduce or remove the effect of conflicts between stakeholders, this issue is inevitable and hence identifying the opposing and contradictory opinions raised from this issue was difficult.

4. Conclusions

This paper presented a new decision-making framework to identify visible problems, relevant responsible stakeholders, and the role of their beliefs in the core phases of industrial wastewater reuse projects (i.e., planning, design, construction and operation) by using both qualitative and quantitative analysis, including stakeholder analysis, CLA, deep mapping and frequency analysis. The methodology was demonstrated by its application to a real case study in industrial parks in Iran. Based on the results obtained, the following can be noted from this study:

- To prioritise the importance of distinct phases of ATU projects, frequency of visible problems per se cannot be considered but timeframe for occurrence of these problems is also important. For example, planning and design phases usually take less time compared to construction and operation phases and any delays in these phases caused by any visible problems can effect more than other phases.
- By connecting the role of responsible stakeholders to visible problems, it can be seen that some stakeholders are responsible for some problems that have no official role. This implies that those problems cannot be addressed through administrative procedures and consequently those with no official role may have to take their own method without accepting their roles.
- Identifying deep beliefs can reveal that most of the deep beliefs are hidden behind the visible problems and consequently original failure causes may never be recognised if these deep beliefs are unidentified properly. Hence, addressing the visible problems is insufficient to satisfy the needs for identifying deep beliefs and even if the problems can be resolved in short-time, but remain unresolved for longer periods.
- The deep mapping implies that the ATU development is a challenging task when only visible problems are considered and reveals the complexity level of problems in the ATU development. Deep roots are connecting complexly to visible problems across the projects core phases. Hence, these beliefs and consequently associated actions can be challenging to understand and resolve.

It seems this study gives opportunities to interested stakeholders to extract and remove the obstacles depending on how they want to face the issue. In other words, while detailed visible problems may be easily

handled in these projects, they may be presented again in short-term or in further projects because their roots are not actually realised. However, beliefs can alleviate the problems over a long-time period but require more budget, significant time and agreement between a wide range of stakeholders. Therefore, integrated and comprehensive assessments are suggested for each strategy in future research works. This assessment can aid to clarify the best option, requiring less financial budget, more willingness for stakeholders to accept and less time duration to plan and operate those strategies that are crucial to make informed decisions by stakeholders.

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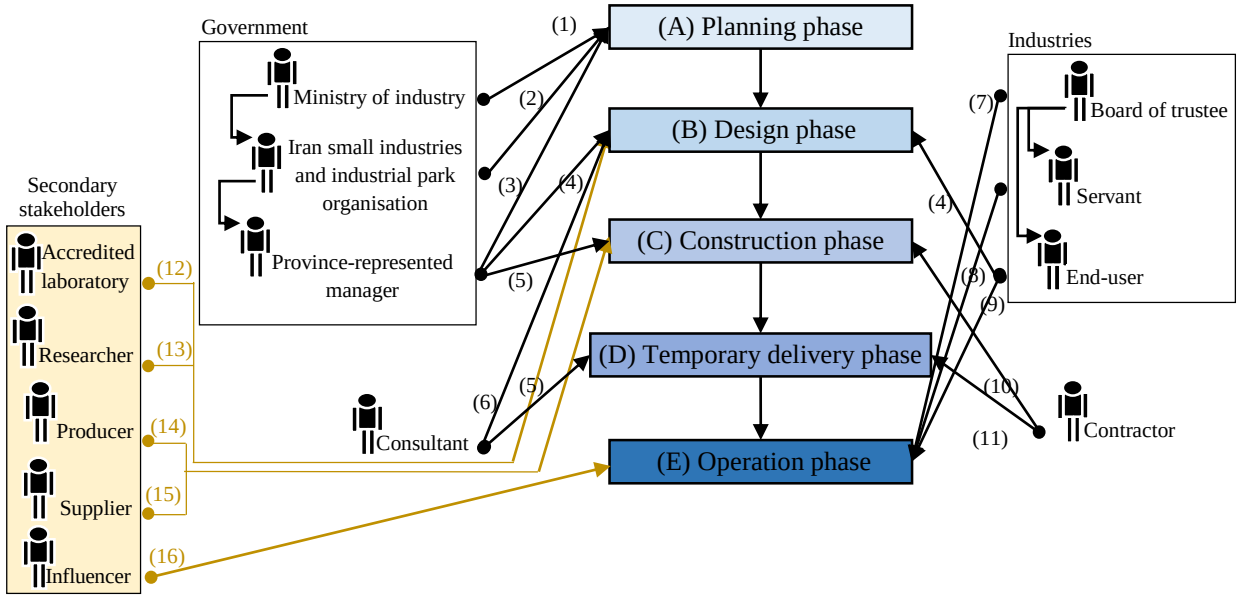
Appendix. Supplementary data

Part A: In-detailed description of case study's identified stakeholders and core phases

The core phases of the ATU development are identified as (1) planning, (2) design, (3) construction, (4) temporary delivery, and (5) operation. Temporary delivering phase is added to recommended core phases because in this phase ATUs are operated by multi-stakeholders, which result in the occurrence of many problems. According to the documents review, core phases of the developing ATUs involve four primary stakeholders including (1) government, (2) consultancies, (3) contractors and (4) industries. The government (i.e., the Ministry of Industry and its subsidiaries in provinces) is mainly responsible for decision making about feasibility studies and developing ATUs in industrial parks. Consultancies provide documents such as the specification of potential ATUs' processes, environmental impact assessment and as-built sheets. Contractors build the treatment plants based on the design conducted by the consultancies and operate the infrastructure in the temporary delivering phase. They finally, deliver the ATUs to industries for permanent operation. While primary stakeholders are found by these documents, secondary stakeholders are added through interview with the representatives of primary stakeholders. Five secondary stakeholders are recognised including, (1) accredit laboratories which are in charge of measuring samples of wastewater quality to provide required design's inputs, (2) researchers i.e. university or research institution to introduce new processes of industrial wastewater reuse, (3) technology providers who are responsible for manufacturing required equipment, (4) suppliers who are responsible for international trading of equipment that is not produced in the country and (5) influencers such as NGOs, religious leaders or community leaders who are responsible for positivity shifting stakeholders' paradigms about reusing treated wastewater.

Project phase	Average lifespan	Processes description
(A)	1 year	- Planning for developing and running the project - Specifying potential locations - Allocating pre-feasibility study's financial budget - Determining rough required budget
(B)	0.5 year	- Data collecting - Design required documents e.g., as-built sheets and EIA reports - Determining economic and social benefit - Clearing future challenges
(C)	1 year	- Providing materials and equipment - Constructing building - Installing equipment
(D)	1 year	- Running the system - Operating for about one year - Diagnostic and fixing the problems - Sharing the knowledge to permanent operator
(E)	25 years	- Monitoring the system - Maintenance the system - Purchasing chemicals or any other required instruments - Selling treated wastewater to end-users



No.	Role in the project
(1)	Deciding about developing and running the feasibility study
(2)	Specifying how issue should be implemented
(3)	Determining and financing the project
(4)	Cooperating in data collection
(5)	Monitoring and reporting about progress
(6)	Feasibility study about the project, Designing and providing as built sheets and documents
(7)	Paying the costs of operation
(8)	Technical operation

No.	Role in the project
(9)	Buying the treated wastewater as new water resource
(10)	Constructing the ATUs
(11)	Temporary operation to realize and remove gaps and faults
(12)	Measuring the quality of wastewater as input of design phase
(13)	R&D about new equipment
(14)	Selling produced equipment
(15)	Selling imported equipment
(16)	Encouraging all the stakeholders to continue and improve the process

Figure A1. Stakeholders involved in Iran's industrial wastewater reuse projects

Table A1. Numbers and types of expertise who are selected for interviewing

Job position	Service time (Year)	Type of stakeholders	Numbers of responders
Politician:			
- Staff of Vice-Presidency	15<	Secondary	1
Government:			
- Manager of Ministry of Industry	15<	Primary	1
- Manager of Iran Small Industries and Industrial Park Organization	15<	Primary	3
- Province-represented manager	5-10	Primary	12
- Supervisor of the industrial park	<5	Primary	6
Industry:			
- Board of trustee of industrial park	<5	Primary	8
- Servant	5-15<	Primary	4
Consultant:			
- Manager	15<	Primary	3
- Designer	5-10	Primary	9
Contractor:			
- Manager	15<	Primary	2
- Staff	<5	Primary	4
Laboratory:			
- Manager	5-10	Secondary	2
- Staff	<5	Secondary	4
Provider:			
- Suppliers	15<	Secondary	1
- Producer	15<	Secondary	1
Researcher:			
- University	15<	Secondary	3
- Institute	5-10	Secondary	2
End user:			
- Manager of industry	15<	Primary	8
Influencer:			
- Manager of non-governmental organization	15<	Secondary	2
- Religious leader	15<	Secondary	1
- Social influencer	<5	Secondary	1
		Total	78

Table A2. Casual layered structure for case study

Phase	Litany layer	Systematic layer	World view layer	Metaphor layer
Planning	1. Technical problem: New innovative technologies are not accepted, and decision makers rely on currently tested technologies	1.1. Government gives no credence to new ideas	1.1.1. Routine works bring more efficiency and risks may cause total failure which ruin all the efforts	1.1.1.1. No systemic thinking
				1.1.1.2. No long-term thinking
			1.1.2. Some senior managers are not trusted by top level managers	1.1.2.1. No meritocracy and criticism flexibility
			1.1.3. A failure in initial steps ruins the whole project	1.1.3.1. No systemic thinking
				1.1.3.2. No long-term thinking
	2. Economic problem: There is no additional or extra financial budget for investment on such these projects	2.1 Government wants to operate the project earlier, even if it runs with set of problems	2.1.1. Some governmental managers introduce the project to improve their resume for political and official offers	2.1.1.1. Quantity-oriented or individualism criteria
		2.2. Government neglects to long-time fully fund the projects	2.2.1. The project inauguration is just for show to present the operation not to perform properly. Therefore, they prefer to investment on operation of quick impact projects	2.2.1.1. Quantity-oriented or individualism criteria
	3.Social problem: All stakeholders do not participate in planning phase	3.1. Government does not properly recognise factory owners as stakeholders	3.1.1. It is factory owners' duty to treat the wastewater. Therefore, it is not necessary to justify the issue for them and government can always coerce them	3.1.1.1. Sense of being wiser than others
			3.1.2. Factory owners only concern about personal benefits. Hence, they have no sufficient vision and understandings.	3.1.2.1. Sense of being wiser than others
			3.1.3. Factory owners do not have sufficient educational level. As a result, their ideas are less worthy of notice	3.1.3.1. Sense of being wiser than others
Design	4. Social problem: Qualified consultant is not selected, and		4.1.1. The least costly option is the best one	4.1.1.1. No long-term integrated thinking

Phase	Litany layer	Systematic layer	World view layer	Metaphor layer
	another consultant cannot design properly.	4.1. Government does not choose the high qualified consultant because of economic limitations	4.1.2. Some employer's members show favouritism and bias	4.1.2.1. Adherence is considered as an anti-value
		4.2. Consultant does not have sufficient education to design properly and do not keep their knowledge up to date.	4.2.1. There is no up to dating in lack of serious rivals	4.2.1.1. Quantity-oriented or individualism criteria
		4.3. Politician in charge of sanctions, which cause inability to upgrade knowledge by consultants.	4.3.1. Foreign governments and consultants are not trustable, and they may want to follow their political goals	4.3.1.1. Insufficient trust between stakeholders
		4.4. Government pressures on consultants to limiting the time of collecting data. Which effect on design quality.	4.4.1. The project inauguration is just for show to present the operation not to perform properly, Therefore, government prefers to invest on quick impact projects.	4.4.1.1. Quantity-oriented or individualism criteria
		4.5. Government pressures on consultants to limiting the financial budget of collecting data.	4.5.1. Government thinks that only essential parameters (like BOD, COD, TSS and TDS) are enough and there is no need for thorough analysis.	4.5.1.1. Sense of being wiser than others
		4.6. Consultant is not informed of some useful domestic capacities.	4.6.1. Foreign products are always better than native ones	4.6.1.1. Westernization
		4.7. Consultant does not use some beneficial international data and experience.	4.7.1. Foreign data is peripheral and not practical in the country	4.7.1.1. Pan-Iranianism

Phase	Litany layer	Systematic layer	World view layer	Metaphor layer
		4.8. Consultant cannot use proper and state-of-the-art software and just provide typical sheets which are not practical in every projects.	4.8.1. Foreign data is peripheral and not practical in the country	4.8.1.1. Pan-Iranianism
		4.9. Qualified consultant cannot present itself properly. Therefore, it is not chosen.	4.9.1. Traditional marketing methods are profitable and there is no need to take new approaches	4.9.1.1. No systemic thinking 4.9.1.2. No long-term integrated thinking
	5. Social problem: Foreign consultants are not recruited.	5.1. Government does not trust to foreign consultants.	5.1.1. Native consultants are preferred to foreign ones due to international relations' difficulties	5.1.1.1. Pan-Iranianism Adherence is considered as an anti-value 5.1.1.2. Deeply gaps
	6. Technical problem: Knowledge are not documented properly for any further sharing.	6.1. Government does not request consultants to give their complete documents.	6.1.1. Some governmental staffs does not find its duty to providing documentation	6.1.1.1. No systemic thinking 6.1.1.2. No long-term integrated thinking
			6.1.2. Some governmental staffs wants the details to be classified because of being open threats one's position	6.1.2.1. Quantity-oriented or individualism criteria
	7. Technical problem: On-line equipment are not installed for providing up to dated design’s input data.	7.1. Government does not support such these costs.	7.1.1. Laboratories are costive units	7.1.1.1. No long-term integrated thinking
			7.1.2. The project must be unique and publishing data may blur this goal	7.1.2.1. Quantity-oriented or individualism criteria

Phase	Litany layer	Systematic layer	World view layer	Metaphor layer
		7.2. Industry does not give its experiences and data to the government or consultants.	7.2.1. There is a fear to be falsely incriminated for leaked data	7.2.1.1.Adherence is considered as an anti-value
			7.2.2. Presenting data shows defects and is considered as a project failure	7.2.2.1. Quantity-oriented or individualism criteria
			7.2.3. There is no need for proper documenting	7.2.3.1. Quantity-oriented or individualism criteria
		7.3. Industry fears that this data can used against them by government.	7.3.1. The government is just looking for penalizing and getting extra money from people and also some governmental managers just think about themselves in preference to provide services	7.3.1.1. Insufficient trust between stakeholders
	8. Social problem: Recent obtained Iranian studies are ignored.	8.1. Consultant and Government do not accept academics. Therefore, they provide insufficient budget for studies.	8.1.1. Studies conduct their experiments on a pilot scale not industrial which provides useless data	8.1.1.1. Deeply gaps
			8.1.2. Academics have no proper experiences and just follow different goals like publishing papers rather than meeting industrial needs	8.1.2.1. Deeply gaps
			8.1.3. There is no need to solve the problem of the industries, because they on which do not need to research, easily are solved. Furthermore, government do not pay sufficient money for proper research	8.1.3.1. Deeply gaps
	9. Social problem: Accredited private laboratories are not hired	9.1. Accredited laboratory has no proper equipment to thoroughly analyse the wastewater samples.	9.1.1. Laboratories do not trust (sometimes true and sometimes wrong) the government to continue its requests. Therefore, they do not invest on equipping their laboratories	9.1.1.1. Insufficient trust between stakeholders

Phase	Litany layer	Systematic layer	World view layer	Metaphor layer
	for determining the required inputs.			
Construction	10. Technical problem: Contractors deliver the project with huge delays	10.1. Government does not complain about contractors' delays, because they fear, it may stop the project.	10.1.1. The project inauguration is just for show to present the operation not to perform properly	10.1.1.1. No systemic thinking 10.1.1.2. No long-term integrated thinking
			10.1.2.The project inauguration is just for show to present the operation not to perform properly, Therefore, government prefer to investment on quick impact projects	10.1.2.1. Quantity-oriented or individualism criteria
		10.2. Contractor heavily looks for illegal economic benefits.	10.2.1. Government has strong financial resources. Therefore, they should be paid more money	10.2.1.1. Adherence is considered as an anti-value
		10.3. Contractor has no adherence to design sheets.	10.3.1. Signing and entering into a contract, equals to monopolizing and owing it	10.3.1.1. Adherence is considered as an anti-value
		10.4. Contractor claims are not considered.	10.4.1. The contractor is always Responsible and blamed	10.4.1.1. Sense of being wiser than others
		10.5. Consultant is not properly supervised in the case of contractors' unreasonable claims.	10.5.1. Sometimes, it is preferred to ignore the standing against contractor in order to have individual benefits.	10.5.1.1. Adherence is considered as an anti-value
	11. Social problem: Qualified contractor is not selected, while others cannot construct properly.	11.1. Government does not choose the high qualified contractors because of economic limitations.	11.1.1. The least costly option is the best one	11.1.1.1 No systemic thinking 11.1.1.2. No long-term integrated thinking
			11.1.2. Some employer's members show favouritism and bias	11.1.2.1. Adherence is considered as an anti-value

Phase	Litany layer	Systematic layer	World view layer	Metaphor layer
		11.2. Native contractor does not have sufficient education to construct properly and do not keep their knowledge up to date.	11.2.1. There is not up to dating in lack of serious rivals	11.2.1.1. Adherence is considered as an anti-value
		11.3. Politician in charge of sanctions, which cause inability to upgrade knowledge by contractor.	11.3.1. Foreign governments and contractors are not trustable, and they may want to follow their political goals	11.3.1.1. Insufficient trust between stakeholders
		11.4. Contractor does not use some beneficial international data and experience.	11.4.1. Foreign data is peripheral and not practical in the country	11.4.1.1. Pan-Iranianism
		11.5. Some qualified Contractors cannot present themselves properly. Therefore, they do not choose the highest qualified contractor.	11.5.1. Traditional marketing methods are profitable and there is no need to take new approaches	11.5.1.1. Having no long-term and systemic thinking
		11.6. Government does not recruit foreign contractors.	11.6.1. Native contractors are preferred to foreign ones	11.6.1.1. Pan-Iranianism
				11.6.1.2. Adherence is considered as an anti-value
			11.6.2. Hiring foreign consultants is not reasonable due to international relations' difficulties	11.6.2.1. Deeply gaps
	12. Economic problem: Foreign component and equipment are expensive and sometimes are unqualified.	12.1. Supplier raises prices, resulting in budget deficit.	12.1.1. Suppliers are exclusive importers and can set rules	12.1.1.1. Adherence is considered as an anti-value
		12.2. Supplier imports fake equipment.	12.2.1. Suppliers are exclusive importers and can set rules	12.2.1.1. Adherence is considered as an anti-value

Phase	Litany layer	Systematic layer	World view layer	Metaphor layer
	13. Technical problem: Foreign component and equipment cannot be provided.	13.1. Politician in charge of sanctions, which cause government inability in proper financial relationship by other foreign companies.	13.1.1. Foreign companies are not trustable, and they may want to follow their political goals.	13.1.1.1. Insufficient trust between stakeholders
	14. Technical problem: Some domestic products have poor quality.	14.1. producer does not product high quality products.	14.1.1. Native producers do not trust (sometimes true and sometimes wrong) the government to continue its requests. Therefore, they do not invest on such these required instruments.	14.1.1.1. Insufficient trust between stakeholders
Temporary delivering	15. Technical problem: Monitoring is not proper.	15.1. Although, Government act like field engineer, they have to pay attention to all other problems of industrial parks. Therefore, there is no time for thorough supervision (Responsible stakeholder: Government)	15.1.1. Giving no credence to governmental supervision	15.1.1.1. No long-term integrated thinking
	16. Technical problem: Main faults are not recognized.	6.1. Contractor does not care about maintenance because they are staff of contractors which just wants to deliver the project as soon as possible.	16.1.1. Economic benefits are just considered	16.1.1.1. Adherence is considered as an anti-value
		16.2. Government takes 10% of contractor's contract and release it many times far away finishing contract. Therefore, contractor does not rely on that and so that does not hire accredited operator.	16.2.1. Government does not want to pay the last part of financial budget and consequently hiring suitable operator is just a costive activity because the government has a history of these type of activities and also some governmental managers just think about themselves in preference to provide services	16.21.1. Insufficient trust between stakeholders

Phase	Litany layer	Systematic layer	World view layer	Metaphor layer
	17. Social problem: Proper operating is not taught to future permanent operators.	17.1. Government and also industry take no responsibility for training operators.	17.1.1. Government just have duty about providing money and supervising for constructing the project and operating is responsible of the trustee board of industries	17.1.1.1. No long-term integrated thinking
			17.1.2. Industries do not know about details of the project and have been forced for delivering the project	17.1.2.1. No long-term integrated thinking
Operation	18. Economic problem: Payments of the loans are not returned in this phase.	18.1. Government provides 50% of the operational costs as a 5-year loan. Only 5% of these loans, however, are paid back in practice by boards of trustees. While the government is not allowed to reprimand and punish them for not returning governmental aids.	18.1.1. The private sectors know they will not be questioned and arraigned because of other laws (like manufacturer protection act) which they can use them against the government	18.1.1.1. Adherence is considered as an anti-value
			18.1.2. Some top-level managers do not care for these problems and have no critical vision about them	18.1.2.1. No long-term integrated thinking
			18.1.3. Private sectors believe that water is a free natural resource and providing it is the government's duty	18.1.3.1. Quantity-oriented or individualism criteria
				18.1.3.2. Adherence is considered as an anti-value
			18.1.4. Private sectors believe that the government is just looking for getting revenue because it has a history of getting financial amount but giving no services in return and also some governmental managers just think about themselves in preference to provide services	18.1.4.1. Insufficient trust between stakeholders
				18.1.5.1. No systemic thinking

Phase	Litany layer	Systematic layer	World view layer	Metaphor layer
			18.1.5. Private sectors believe that it is an opportunity to express their dissidence with government's other policies	18.1.5.2. No long-term integrated thinking
			18.1.6. Private sectors estimate all events by direct cost methods because these projects only have costive consequences	18.1.6.1. No long-term integrated thinking
	19. Social problem: Treated wastewater is not used for primary purpose.	19.1. Industry abuses the treated wastewater for their personal factories and there is no supervision on this issue.	19.1.1. The obtained effluent is a private ownership not public	19.1.1.1. Adherence is considered as an anti-value
	20. Technical problem: Treated wastewater has no proper quantity.	20.1. Industry does not fund to maintenance budgets.	20.1.1. Private sectors believe that water is free as a natural resource and providing it, is the duty of the government	20.1.1.1. Adherence is considered as an anti-value
			20.1.2. These projects are luxury and not really necessary	20.1.2.1. No long-term integrated thinking
		20.2. Industry does not repair and maintenance schedule.	20.2.1. Only in times of disrepair, it is necessary to take action for repairing	20.2.1.1. No long-term integrated thinking
			20.2.2. No one can prove that operators neglect their jobs' duties	20.2.2.1. No long-term integrated thinking
	21. Technical problem: Treated wastewater has no proper quality.	21.1. Industry do not inject required chemicals.	21.1.1. Injecting chemicals is peripheral	21.1.1.1. Adherence is considered as an anti-value
			21.1.2. No one can prove that operators neglect their jobs' duties	21.1.2.1. Adherence is considered as an anti-value

Phase	Litany layer	Systematic layer	World view layer	Metaphor layer
		21.2. Government does not install online control in input quality, which results low quality influent entering into the system and reduce the performance.	21.2.1. Giving no credence to supervision	21.2.1.1. No long-term integrated thinking
		21.3. Industry does not analyse the output effluent's quality.	21.3.1. Only in times of disrepair, it is necessary to take action for repairing	21.3.1.1. No long-term integrated thinking
			21.3.2. No one can prove that operators neglect their jobs' duties	21.3.1.1. Adherence is considered as an anti-value
		21.4. Politician in charge of sanctions, which cause after-sale service is not implemented in Iran.	21.4.1. Foreign companies do not sell their products and some of them may want to follow their political goals.	21.4.1.1. Insufficient trust between stakeholders
	22. Social problem: Operators are not trained properly.	22.1. Industry does not fund the costs.	22.1.1. Training is a costive action	22.1.1.1. No long-term integrated thinking
		22.2. Industry education is irrelevant.	22.2.1. Operating does not require proficiency	22.2.1.1. Adherence is considered as an anti-value
		22.3. Industry is not interested to receive training.	22.3.1. Experience is prior to education	22.3.1.1. Sense of being wiser than others
	23. Social problem: Major faults are not reported to governmental supervisors.	23.1. Industry does not report the problems to the government.	23.1.1. Operators fear from dismissal and deposition	23.1.1.1. Adherence is considered as an anti-value

Phase	Litany layer	Systematic layer	World view layer	Metaphor layer
	24. Social problem: End users do not buy the treated wastewater as a renewable water resource.	24.1. Industry does not trust effluent's quality because it does not trust to government.	24.1.1. The whole system is not trustable, and all stakeholders just think about their goals	24.1.1.1. Insufficient trust between stakeholders
			24.1.2. Some private sectors believe that it is an opportunity to express their dissidence with the boards of trustees' other policies	24.1.2.1. No systemic thinking
		24.2. Influencer does not trust effluent's quality due to insufficient trust to government.	24.2.1. The whole system is not trustable, and all stakeholders just think about their goals	24.2.1.1. Insufficient trust between stakeholders
		24.3. Influencer does not accept the results due to lack of knowledge.	24.3.1. New things must be approved by traditional thinking	24.3.1.1. Sense of being wiser than others

Part B. Detailed results

Table B1. Categories of mentioned perception problems based on the core phases of the case study's project

Core phases	Frequency of responders' general perceptions	Share (%)
Planning	6	7.7
Design	**35**	**44.9**
Construction	3	3.8
Temp. delivery	15	19.2
Operation	19	**24.4**
Total	78	100

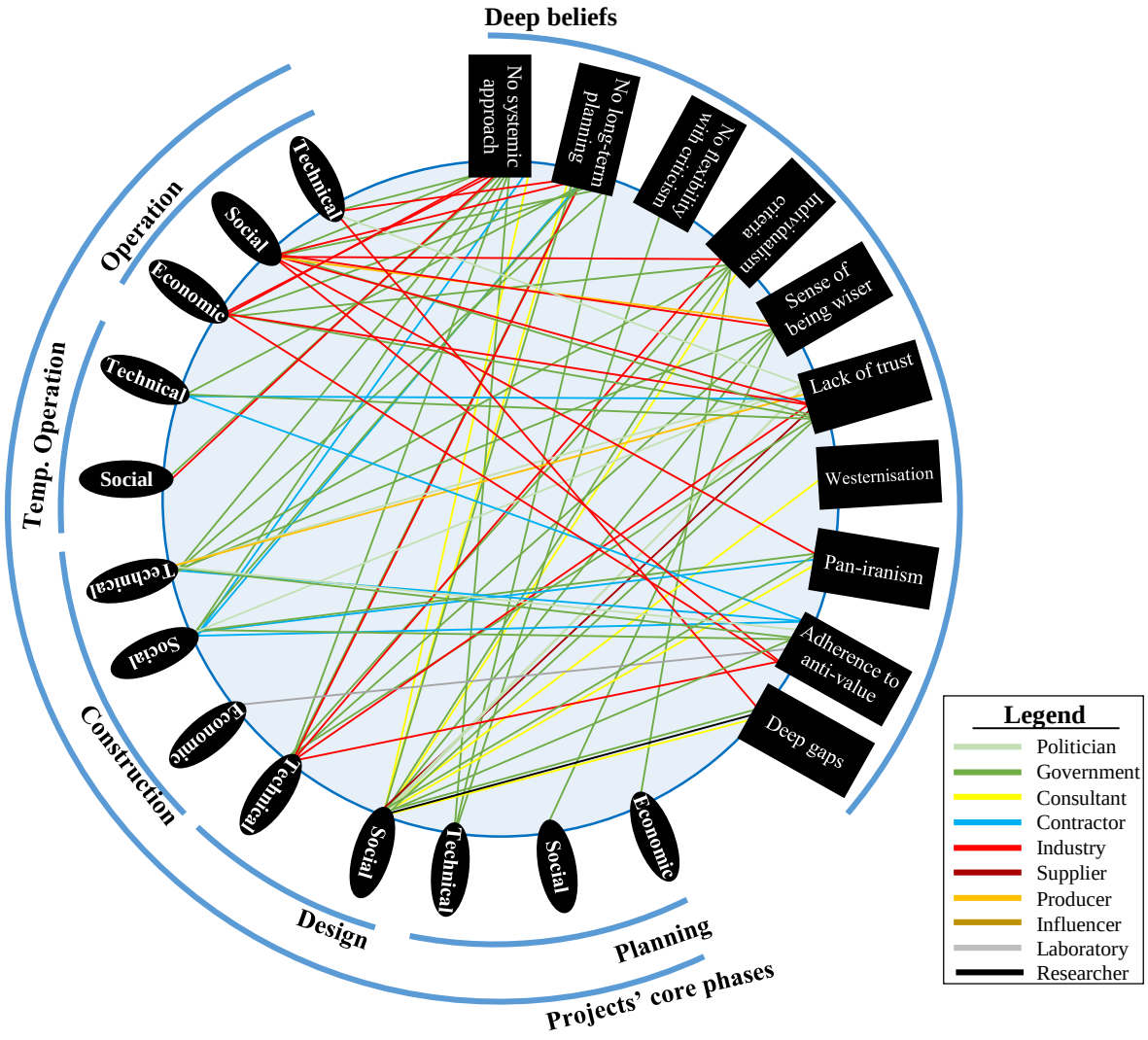


Figure B1. Correlation between identified visible problems, responsible stakeholders, and beliefs through the core phases of ATU projects.