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# The Role of Institutions in the Development of Smart Tank Water Supply Infrastructure Development with the ISM (Interpretative Structural Modeling) Method

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***Abstract:***
*This study aims to develop an institutional model that is suitable for urban development and urban community development, based on ISM (Interpretative Structural Modeling) analysis. ISM analysis results show the key factors that determine the success of the realization of clean water supply infrastructure is government policy, there are 8 main challenges in realizing clean water supply infrastructure based on ISM analysis, namely: (a) There is no connection with the construction of the Smart Tank, (b) the lack of development Smart Tank, (c) there is no Smart Tank development policy, (d) there is no Smart Tank development, (e) Smart Tank criteria are needed, (f) there is no evaluation of the community, (g) there is no Smart Tank design, (h )) there has been no sanctions for the construction of the Smart Tank. In order to realize the fulfillment of clean water supply infrastructure in urban areas in accordance with urban development, suitable institutional models are dissemination and socialization, law enforcement, research, design studies, increased community participation, development of water supply infrastructure, improvement of participatory air supply infrastructure and increased water participation*

***Key Word****:Development; SmartTank; Infrastructure Water Supply; ISM.*

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## I. Introduction

Water Sensitive City (WSC) is a resilience to water security in urban areas. This WSC has 6 urban water system schemes, namely water supply city, sewered city, drainage city, waterways city, watercycles city and water sensitive city (Brown R.R., N. Keath& T.H.F. Wong, 2009). The advantages of the WSC are adequate access to water resources, to ensure socio-technical resilience, and to overcome the system's vulnerability to climate change, and population growth. This WSC scheme is needed to face the challenges that occur in a city so as to be able to utilize water resources holistically and sustainably. The implementation of the above scheme is influenced by population growth, urbanization, and climate change, so that the region is able to have resilient power to meet its water needs. To realize the scheme's water supply infrastructure, a breakthrough and the support of all parties is needed, so that the leap to reach the heart of the WSC can be realized. The development of water infrastructure cannot be separated from the spatial planning policies described in the Spatial Detail Plan (RDTR). In the RDTR regulated zoning and zoning regulations as well as the technical design of utilities, including water infrastructure. The WSC scheme needs to be integrated in the RDTR and the regulations it needs related to its development. The concept of developing WSC infrastructure is shaped by a dominant cultural perspective and has historically instilled urban water values, expressed through institutional arrangements and regulatory frameworks, and is physically represented through a water system infrastructure called the Smart Tank. The realization of the development of Smart Tanks must meet the criteria for infrastructure, facilities and utilities available in urban housing planning, including data and information requirements in order to meet administrative and technical completeness requirements.The new city of Cibinong has a water source that comes from a communal clean water source provided by the Regional Drinking Water Company (PDAM). According to data from PDAM TirtaKahuripan, PDAMs can only serve about 26.46% of clean water from residents of Bogor Regency. Kota Baru Cibinong has only reached 17.36% of service coverage, and even then with limited quality, quantity and continuity. While the rest, residents of the Cibinong urban area meet their clean water needs independently with a non-piping system by utilizing groundwater sources through shallow wells. Development of clean water supply infrastructure needs to be done to meet the above shortage of clean water. One option is to do water harvesting with smart tank technology. At present there is no development pattern for water harvesting and smart tank infrastructure to increase the capacity of clean water supply in urban residential areas. In a series of problems with lack of clean water in urban areas in Cibinong, there are a number of common problems encountered, including: lack of clean water, conventional infrastructure, and the absence of policies regarding the fulfillment of raw water utilization technology. Potential new water sources in urban areas include: rainwater, which is potentially harvested and utilized.

## II. Material And Methods

This research was conducted in the city of Cibinong from September 2017 to June 2019. Data needed in this study included primary data and secondary data. Primary data such as participation, constraints faced in fulfilling clean water supply infrastructure, quality of service, as well as the concept of fulfilling integrated city water supply infrastructure are collected through in-depth interviews with officersdiscussion with experts, and the results of the FGD (Focus Group Discussion) discussion. Whereas secondary data such as population data, socio-economic conditions of the community, water usage per day, characteristics of water supply infrastructure.


**Figure 1.** Location of Cibinong Urban Settlement Area, Bogor, West Java Province

**Model Development Method**

The method used in this study to identify the contextual relationships between components contained in a system and to determine the components that have a major role is the Interpretive Strutural Modeling (ISM) method (Attri et al. 2013). This method is used to identify governance of clean water services which include obstacles encountered in meeting water needs, programs needed, actors and key change targets in various efforts to meet the needs of clean water in Cibinong. ISM is a technique for structuring direct contextual relationships between sub elements in a system (Eriyatno 2012). The methodology with ISM, divided into two parts, namely compiling the hierarchy and classifying sub elements (Eriyatno, 2012). Saxena classifies 9 elements which can be assessed using the ISM method approach (Marimin 2004). The element studied is the constraints faced in meeting water needs, the programs needed, actors and targets of change involved in meeting sustainable water needs. Success in achieving a planned goal / interest is very dependent on the factors actors / stakeholders (Aaltone et al. 2008). The involvement of these elements with their various interests needs to be defined in the contextual relationship between them so that the roles and programs undertaken do not overlap so that the achievement targets can be achieved properly. In general, the stages of analysis can be seen in Figure 6.1.

Determination of sub-elements of each element and identification of contextual relationships between sub-elements is based on expert opinion and the results of extracting information by snowball with initial information coming from the Regent as the Regional Leader who holds the highest authority in the district. In the final part of the analysis phase, values of Driver Power (DP) and Dependence (D) will be obtained to classify the sub-elements of the constraints faced in meeting water needs, required programs, actors and targets of change to identify key sub-elements.

The application of the ISM method follows the following step 2 diagram:

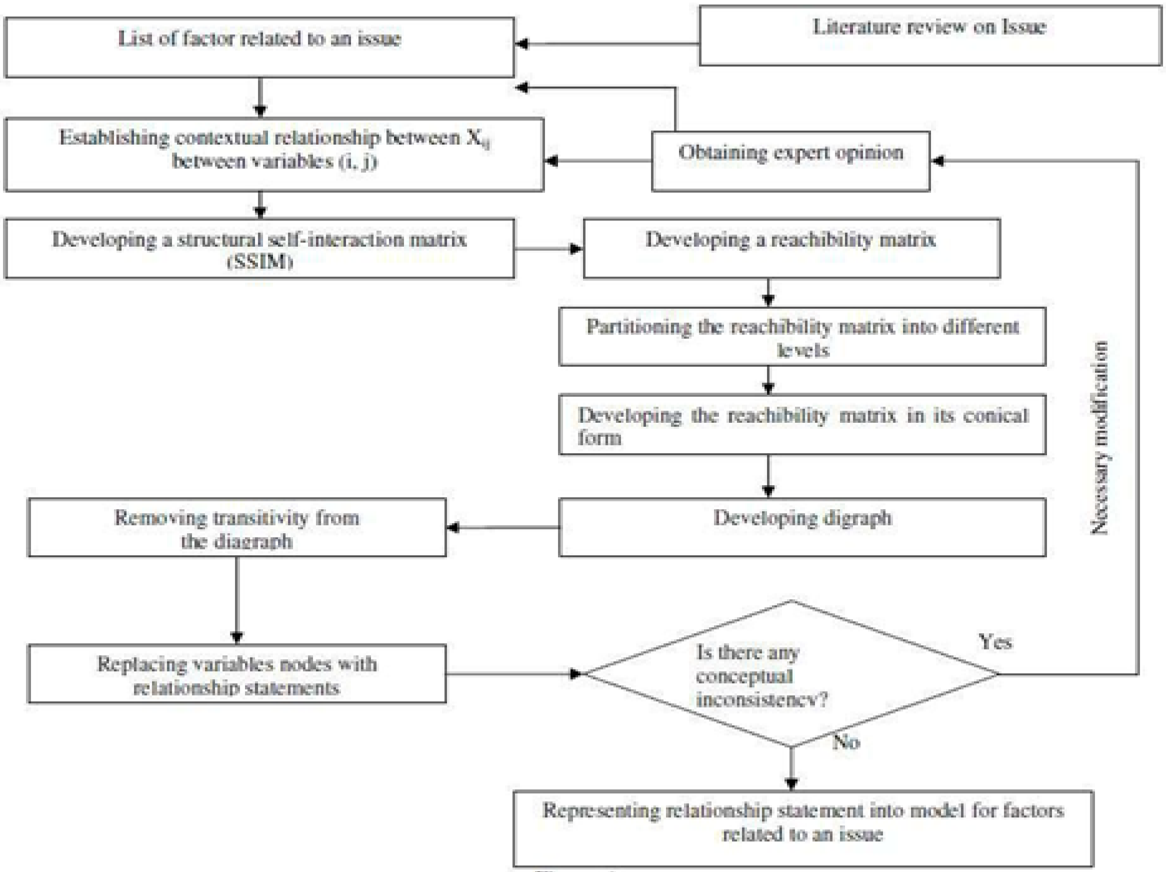


**Figure 2.** Flowchart of the stages of applying the ISM method (Source: Attri et al. 2013)

In this study, based on the results of discussions with experts, 4 elements were dominantly influential in determining the success in fulfilling the water supply infrastructure, namely (1) institutional elements involved in implementing the program, (2) elements of program constraints, (3) elements of change desirable, and (4) elements of the objectives of the program.

**Actors in Fulfilling Clean Water Supply Infrastructure**

For stakeholders / institutions involved in obtaining a model of fulfilling the infrastructure of clean water supply, this research uses the ISM elements of the institutions involved, which will indirectly be related to other elements including the objectives and activities required. While the sub-elements of the institutional elements involved in forming the model are determined by 7 sub-elements, namely: 1. Housing developers 2. Local RT and RW 3.PDAM 4.Private / seller / manufacturer of water tanks 5.PUPR / SDA Service 6.Higher Education 7. Central Government Several studies have described the stakeholders involved in the supply of clean water. Research on the City of Melbourne water supply system categorizes stakeholders into 3 groups namely water resource managers, water users and environmental care groups (Kodikara et al. 2010). Other studies classify stakeholders in the provision of clean water are categorized by decisional level (local, regional and national), by sector (administrative, practitioner, politician, community, association) (Lienert 2013). In this study, the experts agreed to classify actors / stakeholders based on the role of the policy, namely the role as policy maker, policy implementer and role as the party affected by the policy. The central government and universities describe the role of policy makers (regulators). The institution is an institution that makes policies, development directions and strategies for developing the clean water sector both at the district and national levels. Various technical services related to meeting the needs of clean water, PDAM and the PUPR / SDA service illustrate the role of implementing regulations. This institution plays a role in implementing clean water development policies and conducting technical actions in the provision of clean water for the community. Whereas local housing, RT and RW developers, and private parties related to efforts to meet clean water needs illustrate the role of those affected by the policy. The various policies determined and the efforts made are aimed at having a positive impact in meeting water needs for the community. The type of contextual relationship between sub-elements specified is influence / influence. The sub-elements of one institution affect or support the fulfillment of other sub-elements of the institution. The results of the expert opinion aggregation, the contextual relationship between the sub-elements of the institutions involved in the fulfillment of the water supply infrastructure as contained in table 7.3 of the following SSIM.

Table 1.structuralself interaction matrix (SSIM) institutions involved in the development of water supply infrastructure.

| No. Urut | Culprit | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|
| 1 | Housing developer | A | O | A | V | O | V | |
| 2 | Local RT and RW | O | O | O | V | O | | |
| 3 | PDAM | A | A | X | V | | | |
| 4 | Private / Seller / manufacturer of water tanks | A | A | A | | | | |
| 5 | PUPR / SDA Service | A | A | | | | | |
| 6 | College | O | | | | | | |
| 7 | Central government | | | | | | | |

Furthermore, the result data from the SSIM table is converted in binary 1 and 0 matrices to the initial reachability matrix. The results of the conversion as shown in Table 7.4

Table 2. Initial Reachability Matrix (IRM) structure of institutional roles in the development of water supply infrastructure

| No. Urut | Culprit | P1 | P2 | P3 | P4 | P5 | P6 | P7 |
|---|---|---|---|---|---|---|---|---|
| P1 | Housing developer | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| P2 | Local RT and RW | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| P3 | PDAM | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| P4 | Private / Seller / manufacturer of water tanks | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| P5 | PUPR / SDA Service | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| P6 | College | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| P7 | Central government | 1 | 0 | 1 | 1 | 1 | 0 | 1 |

The IRM table is then corrected by the transitivity principle until a final reachability matrix (FRM) is produced (Table 3). Through FRM, the level of dependence power (dependency) and driver power (driving force) as well as the rank / level of each sub-element of fulfilling the infrastructure of clean water supply can be determined.

Table 3.Final Reachability Matrix (FRM) structure of institutional roles in the development of clean water supply infrastructure.

| *Sub Elemen* Culprit | *P1* | *P2* | *P3* | *P4* | *P5* | *P6* | *P7* | *Drive Pwr* | *Rank* |
|---|---|---|---|---|---|---|---|---|---|
| *P1* | *1* | *1* | *0* | *1* | *0* | *0* | *0* | *3* | *III* |
| *P2* | *0* | *1* | *0* | *1* | *0* | *0* | *0* | *2* | *IV* |
| *P3* | *1* | *1* | *1* | *1* | *1* | *0* | *0* | *5* | *II* |
| *P4* | *0* | *0* | *0* | *1* | *0* | *0* | *0* | *1* | *V* |
| *P5* | *1* | *1* | *1* | *1* | *1* | *0* | *0* | *5* | *II* |
| *P6* | *1* | *1* | *1* | *1* | *1* | *1* | *0* | *6* | *I* |
| *P7* | *1* | *1* | *1* | *1* | *1* | *0* | *1* | *6* | *I* |
| *Dep. Pwr* | *5* | *6* | *4* | *7* | *4* | *1* | *1* | | |
| *Rank* | *III* | *II* | *IV* | *I* | *IV* | *V* | *V* | | |

The final results of processing contextual relations as contained in the FRM table above shows that sub-elements P6 (Higher Education) and sub-elements P7 (Central Government) have the highest thrust or driving force compared to other sub-elements. This implies that the two sub-elements have a very significant influence on the system, or on the success of the program to fulfill the water supply infrastructure. The failure of the central government and the role of tertiary institutions will negatively affect the system, and hence influence the optimization of the realization of the fulfillment of clean water infrastructure. A clearer illustration related to the level of power drivers and dependencies of each sub-element of the institution fulfilling the infrastructure of clean water supply can be seen in Figure 1. Related images map the location of each sub-element in four quadrants.

## III. Result

**Actors in Fulfilling Clean Water Supply Infrastructure**

This element is broken down into 7 sub-elements, namely: (1) Housing developers, (2) Local RT and RW, (3) PDAM, (4) Private / seller / manufacturer of water tanks, (5) Dinas PUPR / SDA, (6 ) Higher Education, (7) Central Government.

The analysis shows that the higher education sub-element (P6) and the central government sub-element (P7) have the highest driving force or movers compared to other sub-elements. This implies that the two sub-elements have a very significant influence on the system, or on the success of the program to fulfill the water supply infrastructure. The failure of the central government and the role of tertiary institutions will negatively affect the system, and hence influence the optimization of the realization of the fulfillment of clean water infrastructure. A clearer illustration related to the level of power driver and dependence of each sub-element of the institution fulfilling the infrastructure of clean water supply can be seen in Figure 3 and the diagram of the actor's hierarchical structure model in Figure 4.

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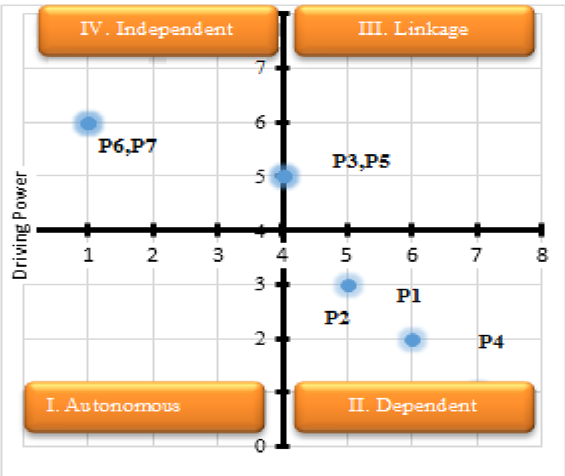



Figure 3.Relationship of power drivers and dependencies on the perpetrators

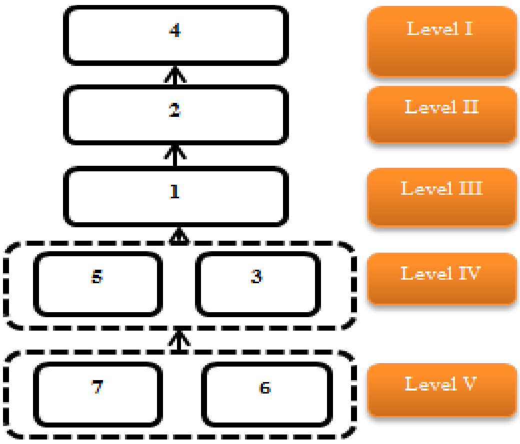
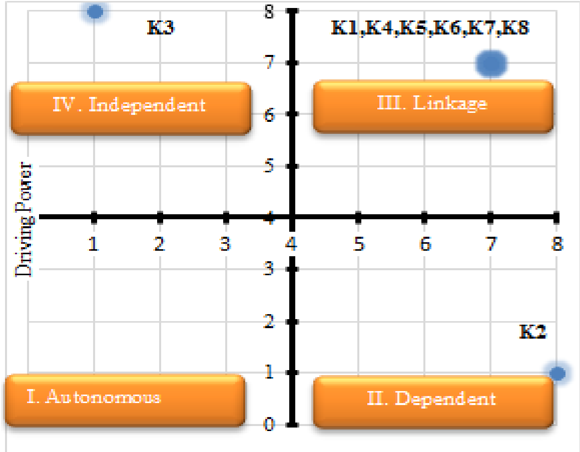



Figure 4. Model Diagram of the Actor's Hierarchy Structure

Sub-elements Housing developers (P1), local RT and RW (P2), and Private / Seller / producer of water tanks (P4), occupy quadrant II (Dependent), meaning that the three sub-elements have a high dependency to other sub-elements, and has weak thrust or driving force. Local housing, RT and RW sub-elements, and private / seller / water tank producers are not free, because they are very dependent on other elements in the system.

There are 2 (two) sub elements classified into quadrant III (Linkage), and into quadrant IV (Independent) PDAM (P3), and the PUPR / SDA service (P5). The existence of these two sub elements is in the middle position between the quadrants III and IV quadrants, indicating that they have a high enough propulsion or driving force, but also have a high enough dependency, also have a high thrust and independence (weak dependence ). The two sub elements in quadrant III and quadrant IV require careful study and consideration in their application, because they have unstable relationships between sub elements in the system.

Constraints in Fulfilling Clean Water Supply Infrastructure The main obstacles to the program to fulfill the clean water supply infrastructure are divided into 8 sub-elements, namely: (1) The absence of regulations on the construction of smart tanks, (2) The lack of construction of smart tanks, (3) The absence of smart tank development policies, (4) Not yet the existence of smart tank management, (5) Need for smart tank criteria, (6) There are no sanctions against the community, (7) There is no smart tank design, (8) There are no sanctions for the construction of smart tanks. From the 8 sub-elements, the analysis shows that the sub-element of the smart tank (K3) development policy has not yet had the highest thrust or driving force compared to other sub-elements. This implies that the K3 sub-element has a very significant influence on the system, or on the success of the program to fulfill the water supply infrastructure. Failure in the smart tank development policy will negatively affect the system, and therefore affect the optimization of the fulfillment of water supply infrastructure. The relationship between the power driver and the dependence of each of the sub-elements of the program constraints in fulfilling the infrastructure of the clean water supply can be seen in Figure 5 and a diagram of the hierarchical structure model for the program constraints in Figure 6.



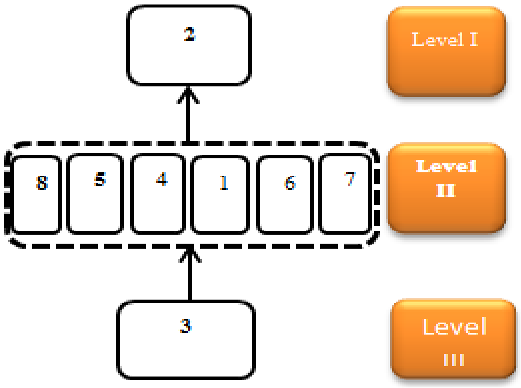




Figure 5.Relationship of power drivers and dependencies on destination elements

Figure 6. Diagram of the Constrained Hierarchy Structure Model

Sub elements The minimum construction of smart tanks (K2) occupies quadrant II (Dependent), meaning that these sub elements have a high dependency to other sub elements, and have a driving force or a weak driving force. Sub elements The lack of smart tank construction is not free, because it is very dependent on other elements in the system.

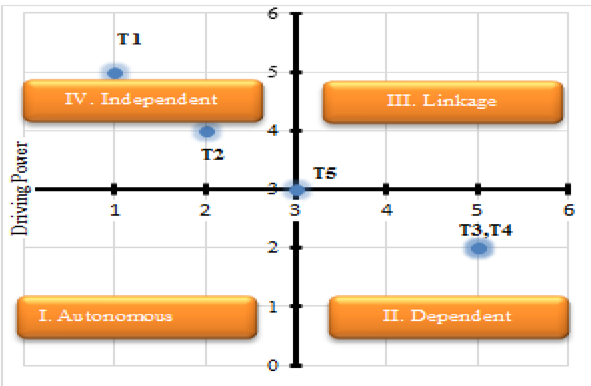
There are 6 (six) sub elements that are classified into quadrant III (Linkage), namely there is no regulation on the construction of smart tanks (K1), there is no management of smart tanks (4), smart tank criteria are needed (5), there are no sanctions against the community (6), the absence of smart tank design (7) There is no sanction for the construction of smart tanks (8). The existence of the six sub-elements in quadrant III indicates that they have a high enough propulsion or driving force, but also have a high enough dependency.

Changes in Fulfilling Clean Water Supply Infrastructure

The elements of change desired by the program are broken down into 5 sub-elements, namely: (1) Increasing dissemination and dissemination completely, (2) Increasing understanding of the importance of building Smart Tanks, (3) Increasing consistency in the application of smart tank regulations, (4) Smart law enforcement tank, (5) participatory design.

The results of the analysis show that the complete increase in dissemination and dissemination (T1) sub-elements has the highest thrust or driving force compared to other sub-elements. This suggests that these sub-elements have a very significant influence on the system, or on the success of the program to fulfill the water supply infrastructure.

In addition to that which has a high thrust is a sub-element of increasing understanding of the importance of building smart tanks (T2). By providing an understanding of the importance of building smart tanks for the community, it is hoped that the community will participate in supporting the fulfillment of clean water infrastructure. The relationship between sub-elements of changes in the program to fulfill the clean water supply infrastructure can be seen in Figure 7 and the change in the hierarchical structure model figure 8.



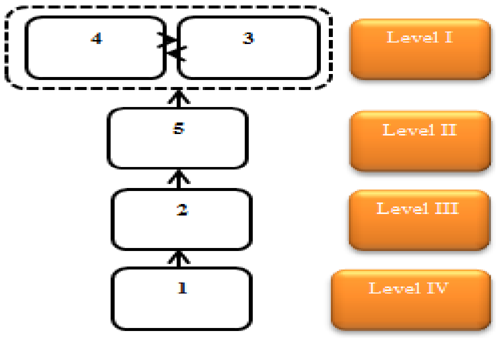




Figure 7.Relationship of power drivers and dependence on elements of change

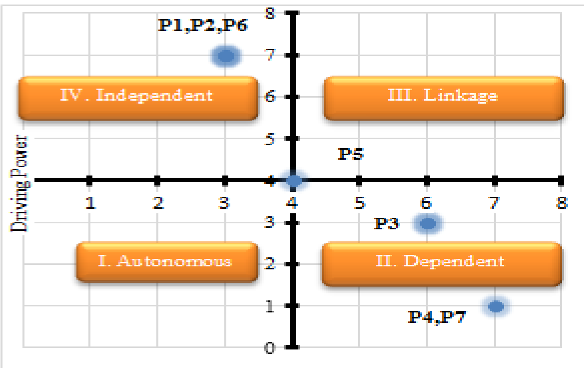
Figure 8. Diagram of the Changing Hierarchy Structure Model

Sub elements Increased consistency in the application of Smart Tank (T3) and Law Enforcement Smart Tank (T4) occupies quadrant II (Dependent), meaning that both sub elements have a high dependency to other sub elements, and have a driving force or a weak driving force . Sub elements Increased consistency in the application of Smart Tank regulations and law enforcement Smart Tanks are not free, because it is very dependent on other elements in the system.

**Programs in Fulfilling Clean Water Supply Infrastructure**

The results of discussions with experts, relevant parties and research in the field, the elements of the program's objectives are broken down into 7 sub elements, namely: (1) Dissemination and outreach, (2) Enforcement of law, (3) Improvement of community participation, (4) Improvement of infrastructure water supply, (5) Increased water availability, (6) Research, design studies, (7) Participatory water supply infrastructure availability.

The results of the analysis of the 7 sub-elements of the program's objectives show that the key sub-elements of the program's objective elements are the dissemination and socialization (P1), law enforcement sub-elements (P2), and research sub-elements, design studies (P6 ). has the highest thrust or propulsion compared to other sub-elements. This implies that the three sub-elements have a very significant influence on the system, or on the success of the water supply infrastructure fulfillment program. Failure of dissemination and socialization, law enforcement, and research, design studies will negatively affect the system, and therefore affect the optimization of the fulfillment of clean water supply infrastructure. The relationship between the sub-elements of program activities to fulfill the water supply infrastructure can be seen in Figure 9 and Figure 10 diagram of the program hierarchy model activities



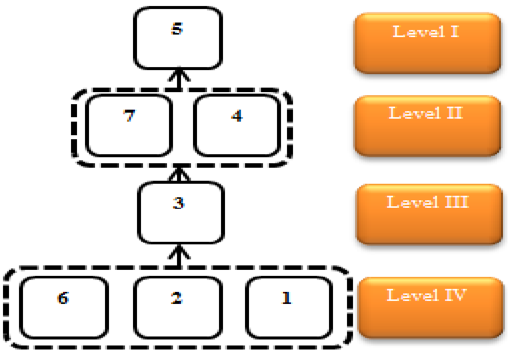




Figure 9.Relationship of power drivers and dependencies on program elements

Figure 10. Model Diagram of Program Hierarchy activities

Sub elements of water supply infrastructure improvement (P4), increase in water availability (P5), and availability of participatory water supply infrastructure (P7) occupy quadrant II (Dependent), meaning that the three sub elements have a high dependence on other sub elements, and has weak thrust or driving force. Sub elements Improvement of water supply infrastructure, Increased water availability, and availability of participatory water supply infrastructure are not free, because it is very dependent on other elements in the system. Linkages between Key Elements in the Institutional System in Fulfilling Clean Water Supply Infrastructure in the Cibinong Urban Settlement Area The output of the institutional system in the form of goals and changes to be achieved in meeting the needs of clean water. The main objective of fulfilling clean water supply infrastructure is to maintain the function of water infrastructure as a water reservoir. This goal can be achieved if the reservoir can function optimally, which can provide water throughout the year, both in the rainy season and the dry season. The changes that are made possible from the system to achieve these goals are increasing dissemination and thorough socialization, as well as increasing understanding of the importance of building Smart Tanks. Based on the Interpretative Structure Modeling analysis, the institutional role system model in meeting the clean water supply infrastructure is presented in Figure 11.

INSTITUTIONAL ROLE STRUCTURE OF THE ROLE OF THE PERSON, CONSTRAINTS, CHANGES IN THE PROGRAM

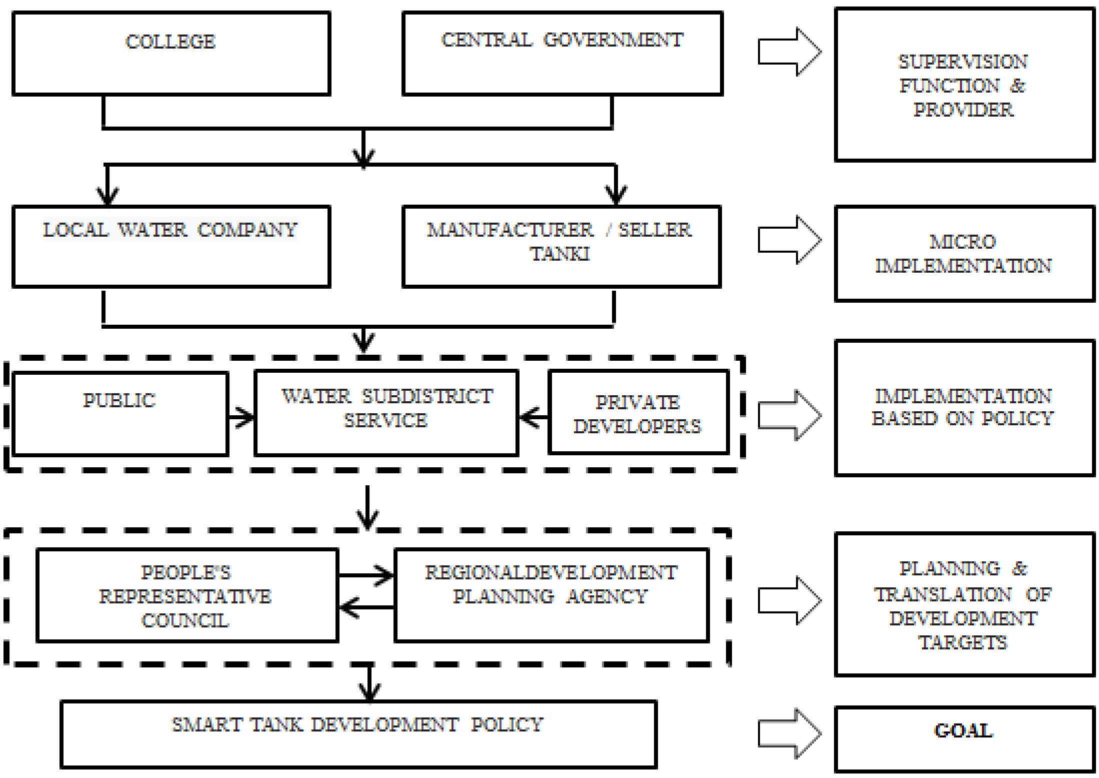



**Figure 11.** Structure model development of the role of institutions in meeting the water supply infrastructure

The constraints of the sub-elements of the analysis show that the sub-element of the smart tank (K3) development policy has not yet had the highest thrust or driving force compared to other sub-elements. This implies that the K3 sub-element has a very significant influence on the system, or on the success of the program to fulfill the water supply infrastructure

Program, The results of the analysis of the 7 sub-elements of the program's objectives show that the key sub-elements of the program's objective elements are the dissemination and socialization (P1), law enforcement sub-elements (P2), and research sub-elements, design studies (P6).has the highest thrust or propulsion compared to other sub-elements. This implies that the three sub-elements have a very significant influence on the system, or on the success of the water supply infrastructure fulfillment program.

Changes, the results of the analysis show that the sub-element of increased dissemination and dissemination completely (T1) has the highest driving force or movers compared to other sub-elements. This suggests that these sub-elements have a very significant influence on the system, or on the success of the program to fulfill the water supply infrastructure.

Perpetrators, the analysis shows that the higher education sub-element (P6) and the central government sub-element (P7) have the highest driving force or movers compared to other sub-elements. This implies that the two sub-elements have a very significant influence on the system, or on the success of the water supply infrastructure fulfillment program.

To realize the problem of the smart tank development and construction policy, collaboration between parties is needed. Other major obstacles that need to be addressed are the problem of the absence of smart tank management and sanctions against the community.

The main need for fulfilling clean water supply infrastructure is in the form of smart tank development policy as outlined in the regulation of smart tank development.

The main actors in fulfilling the clean water supply infrastructure are the central government and universities. Both of these actors have great mobility that can encourage other actors to get involved in fulfilling clean water supply infrastructure. The synergy between the two actors in developing an institutional system will determine the success in meeting the needs of clean water.

## IV. Conclusion

The analysis shows that the role of the central government is very strategic in the efforts to fulfill the infrastructure of clean water supply in the regions. The absence of a smart tank development policy from the government is the main obstacle faced in the efforts to fulfill the water supply infrastructure. Related to the main (key) program needed as an effort to fulfill the clean water supply infrastructure in the urban residential area of Cibinong including making blueprints for regulation of smart tank construction, smart tank management, smart tank criteria, sanctions against the community, smart tank design, and smart development sanctions tanks as the main factor for realizing clean water supply infrastructure. The main actors in the effort to fulfill this clean water supply infrastructure are the central government and universities as designers of smart tanks. While the main target of the changes expected from efforts to meet the infrastructure of clean water supply is to increase dissemination and dissemination thoroughly and increase understanding of the importance of building smart tanks, so that community rights in the form of clean water can be fulfilled.

### Suggestion

Further research needs to be done especially relating to the dissemination and socialization of the fulfillment of clean water supply infrastructure, law enforcement, and study of clean water supply infrastructure design, in accordance with urban development and community development. The main constraints faced in providing clean water supply infrastructure in urban residential areas are the absence of a smart tank development policy, the absence of regulation on the construction of a smart tank; for that we need criteria and design of smart tanks so that the construction of smart tanks can be realized.

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