


# **A Concept on Integrated Groundwater Management to Sustain Cities in Indonesia using System Interrelationship Model**



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# Introduction

- Indonesia as a developing country
- The city is indicated by high density of people, very limited infrastructure and public services on sanitation
- Slow moving forward in development
- Low percentage of public awareness on sanitation or environment
- This is a proposed concept from scientific point of view
- A new concept based on the application of **THINKING TECHNIQUE; ARTIFICIAL INTELLIGENCE IN ENGINEERING; and OBJECT ORIENTED PROGRAMMING**

# Introduction

## Fact

- Water supply infrastructure is very limited
- In a city, high rate of population increment
- Factory, Hotel, Office, and Private house exploit groundwater

## Consequence

- Conflict on water resources
- Reduce percolation rates as there are some squatter
- Sanitation is bad
- Reducing human health
- Seawater intrusion
- Permanent water table – drawdown

## Effort

- Classical effort: limitation & control on groundwater abstraction
- Imposing government regulation

# Basic Concept of System Interrelationship Model

```
write("Pilih industri yang akan diidentifikasi : "),readln>Nama_ind),nl,
cari_data_ind>Nama_ind),nl,
data_ind>Nama_ind,Qkeb_ind,Qpdam,Qap,Qsmr),
upaya_rasio_ind>R3,R4,Rasio_ind),
solusi_sp_ind>Rasio_ind,Inform),
Batas_zona>Zona_Obts1,Obts2,Bts_debit)
```

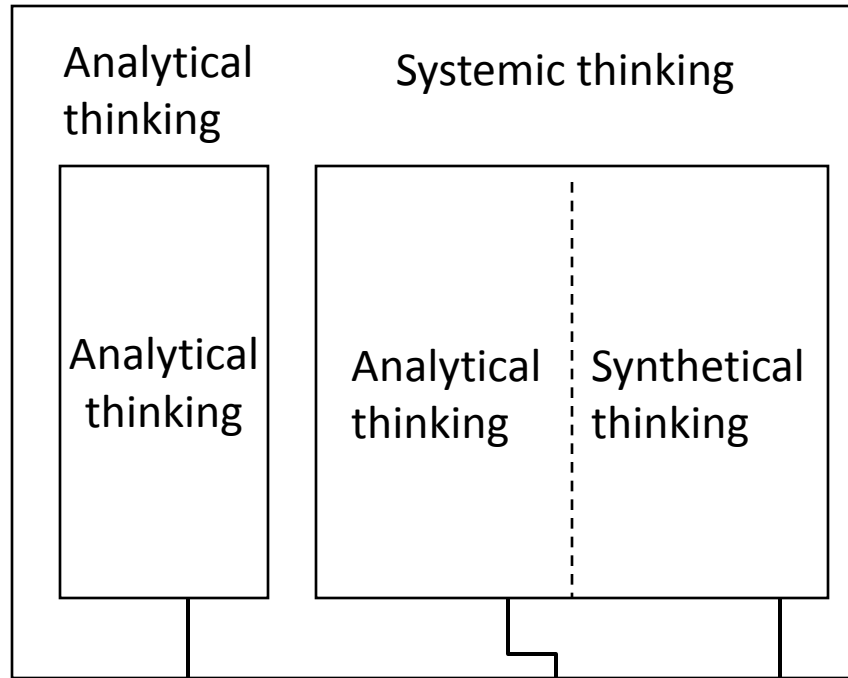
- Systemic Thinking is a technique to see problems in a wide-focus version.
- Systems Thinking is a technique to find how things interact with one another in a system
- Artificial intelligence is trying to imitate human (expert) reasoning in an autonomous way

```
write("*****"),nl,nl,
write("Pelayanan PDAM pada Kec. ",Nama_kec," ",Rasio_pdam),nl,nl,
solusi_1_pdam>Rasio_pdam,Upy_atdlm1),
write("sehingga upaya yang perlu dilakukan PDAM :"),nl,
write(Upy_atdlm1),nl,nl.
cari_pengaruh_elemen(_, "pdam", "industri").

cari_pengaruh_elemen>Nama_kec, "industri", "pdam"):-
clearwindow,
ketentuan_zona>Nama_kec,_,_,Zona),
write("Melakukan identifikasi layanan PDAM terhadap industri"),nl,
cari_jenis_ind>Nama_kec),
write("Pilih jenis industri : "),readln>Jns_ind),nl,
cari_nama_ind>Nama_kec,Jns_ind),
write("Pilih industri yang akan diidentifikasi : "),readln>Nama_ind),nl,
cari_data_ind>Nama_ind),nl,
data_ind>Nama_ind,Qkeb_ind,Qpdam,Qap,Qsmr),
```

# Basic Concept of System Interrelationship Model

## Mental frame to understand 'systemic thinking'



Conventional thinking technique =  
analytic

Analytical thinking is about analyzing  
a situation that consists of parts or  
components

Synthetical thinking is about how the  
components works together

Conventional thinking technique

How the components  
Work together

*(Bartlett ,2001)*

# Basic Concept of System Interrelationship Model

```
write("Pilih industri yang akan diidentifikasi : "),readln>Nama_ind),nl,
cari_data_ind>Nama_ind),nl,
data_ind>Nama_ind,Qkeb_ind,Qpdam,Qap,Qsmr)
```

## Representation of Knowledge, Description, and Relation

Relation entity  $x$  and  $y$ ,  
example:

Attribute  $R$  of an object  $x$  has a value  $y$   
 $x$ ,  $y$  can be a symbol, value, or concept

To modeling  $x$  and  $R$  is an argument of a function written as  $f_y$

Can be written as:

$$y = f_y(x, R)$$

If a domain  $x$  and  $R$  is finite set, the relation can be written as:  $(R, x, y)$

Or (Attribute, object, value)

Or  $(A, O, V)$  is read as 'A of O is V'

As an alternative it can be shown as 'relation'

' $x$  is related to  $y$  by  $R$ '

In graph

$$x \xrightarrow{R} y$$

```
cari_nama_ind>Nama_kec,Jns_ind),
write("Pilih industri yang akan diidentifikasi : "),readln>Nama_ind),nl,
cari_data_ind>Nama_ind),nl,
data_ind>Nama_ind,Qkeb_ind,Qpdam,Qap,Qsmr),
```

# Basic Concept of System Interrelationship Model

Example of relation:

Binary relation involves two sets, relates the member of the set

Example of relation is used for relating data of an image (image data)

$L = \{a, b, c, d\}$

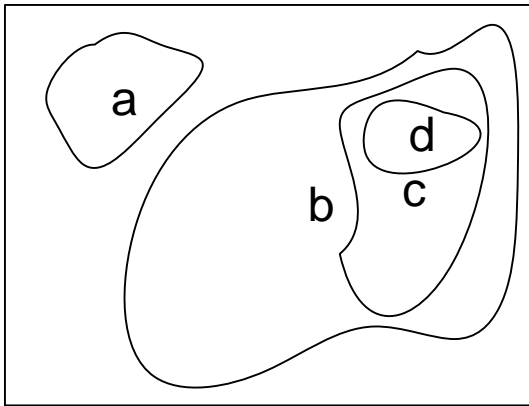
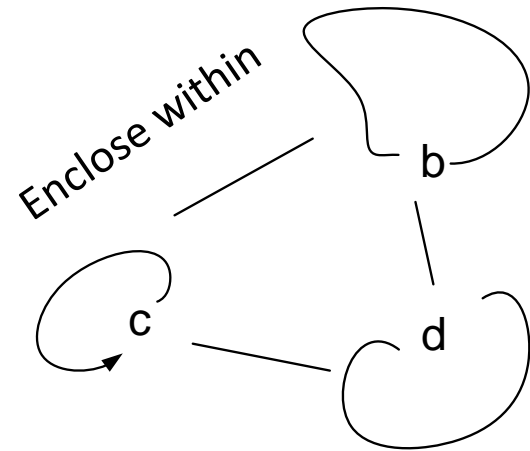
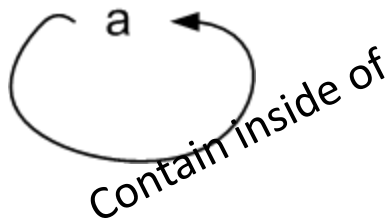


Image data (region)  
(a)



Relation "contain in" For an area as fig(a)  
In the form of digraph(directed graph)

# Basic Concept of System Interrelationship Model

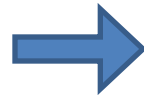
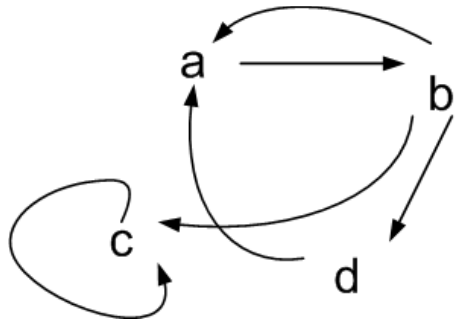
## Semantic Net

From digraph to semantic net

Graphics can indicate relations of values, symbols (entity) of a set

Semantic net as a digraph to describe relation (including property) of an object, concept, situation, or actions.

A mechanism to “get started” in the development of knowledge Representation



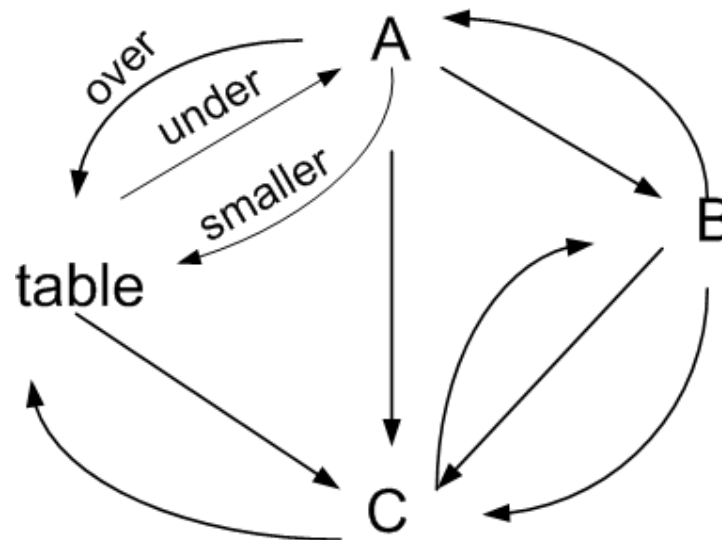
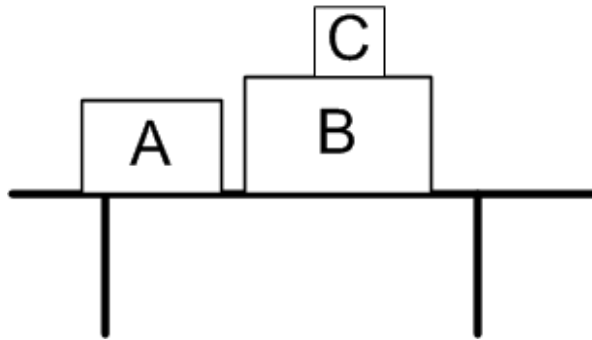
Digraph of R=  
 $\{(a,b),(b,c),(b,d),(b,a),(c,c),(d,a)\}$

The entire Semantic Net is usually large and highly interconnected entity

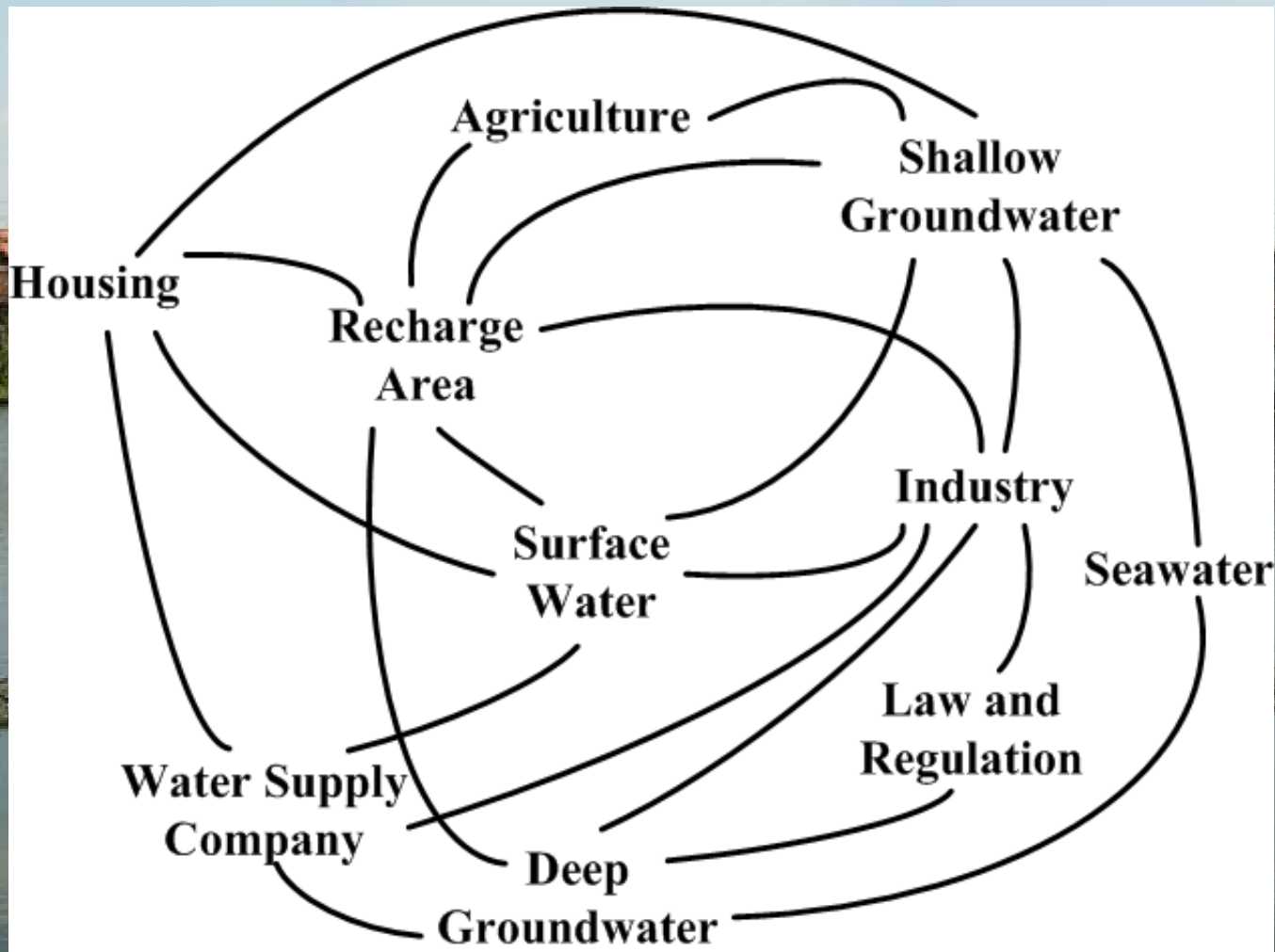
# Basic Concept of System Interrelationship Model

## An example of a Semantic Net

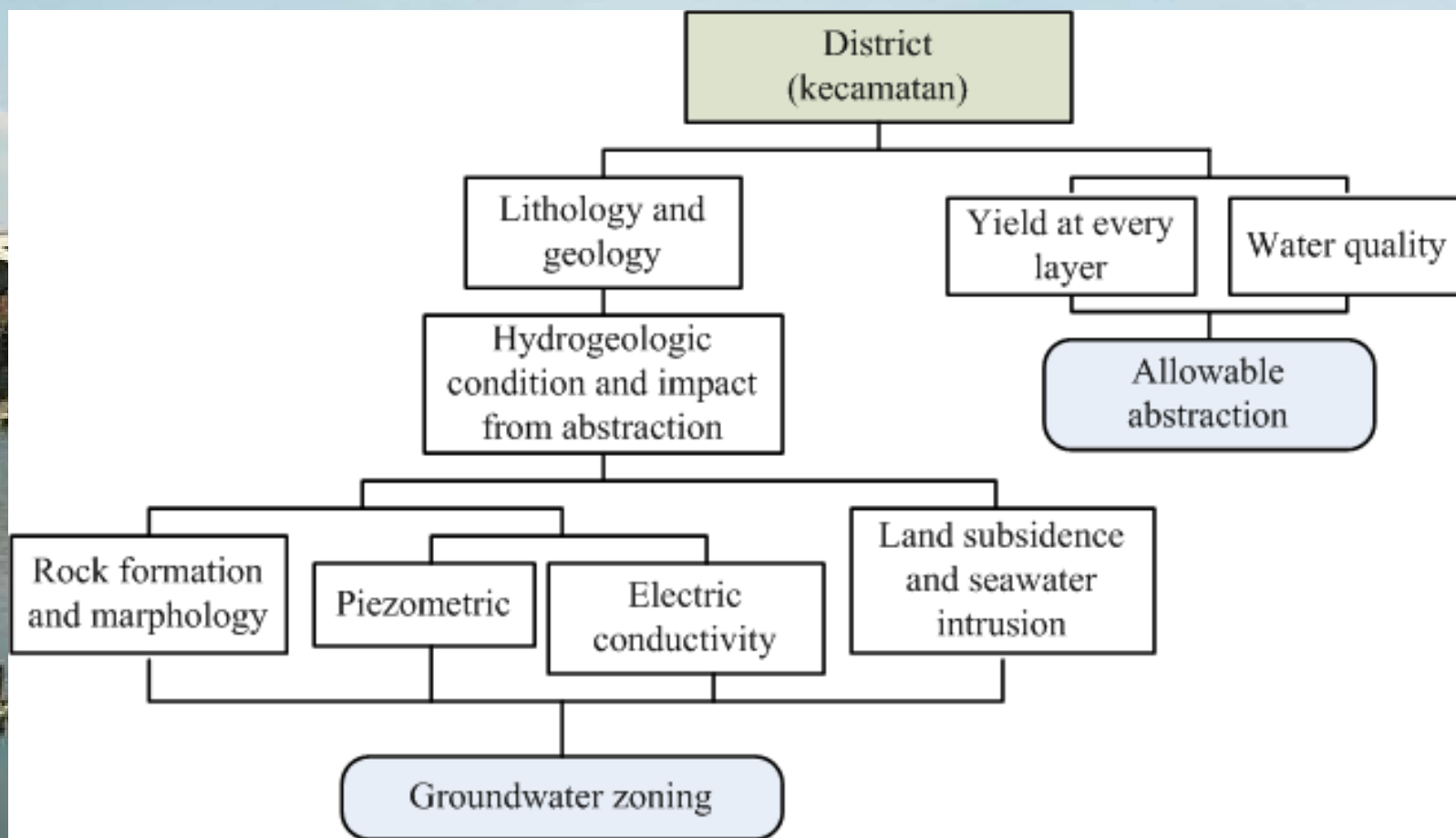
A Semantic Net represent object as node and relation as line



# The System Interrelationship Model of Groundwater in Cities

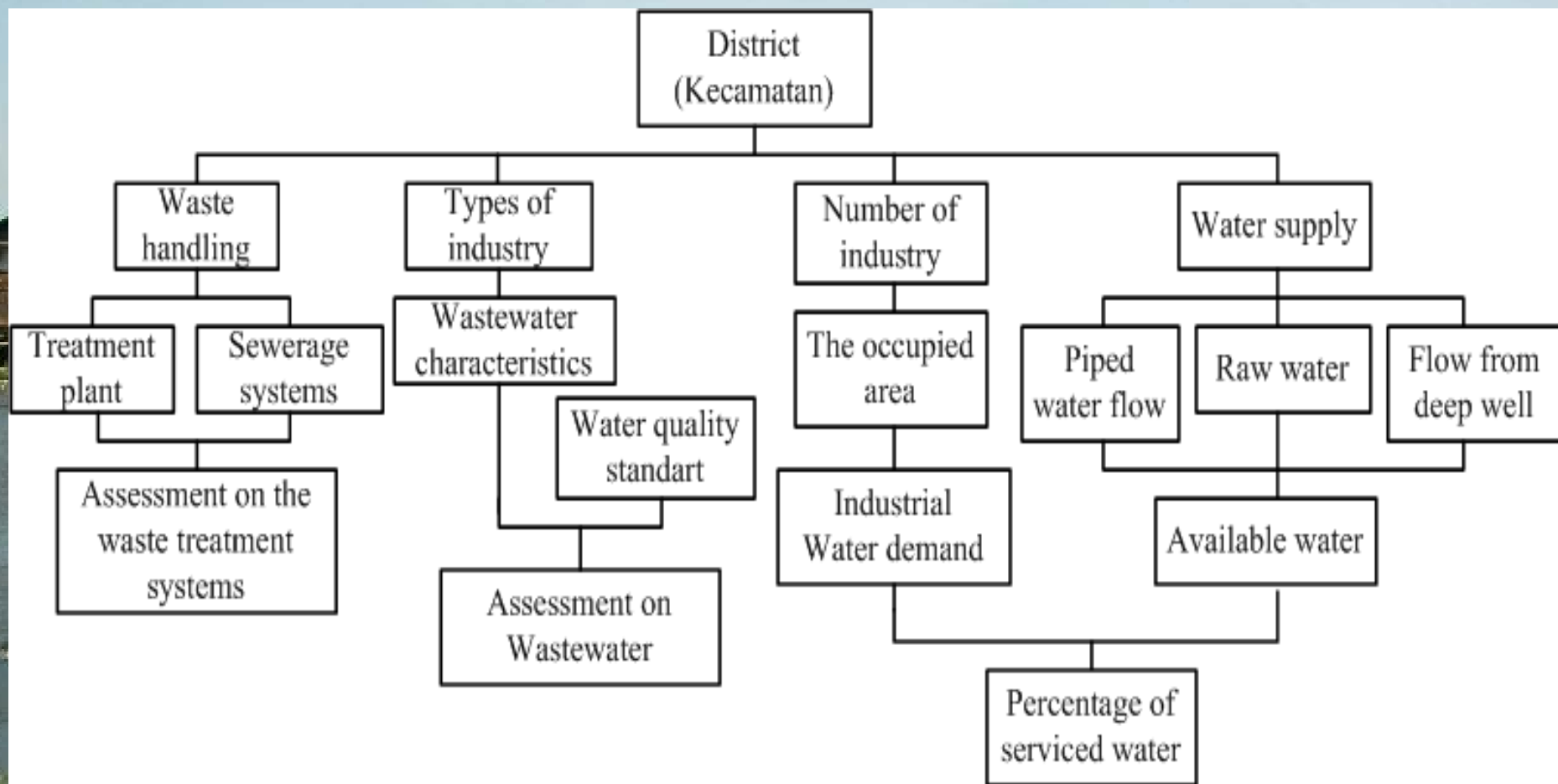


# The System Interrelationship Model of Groundwater in Cities



The Knowledge on Groundwater

# The System Interrelationship Model of Groundwater in Cities



**The Knowledge on Industry**

# The System Interrelationship Model of Groundwater in Cities

Component	Influential Components	Data Required	Explanation
Groundwater	Water supply company	<ul style="list-style-type: none"> <li>▪ Flow of groundwater abstraction;</li> <li>▪ Service area</li> </ul>	the water table may decrease rapidly
	Recharge area	<ul style="list-style-type: none"> <li>▪ Soil characteristic;</li> <li>▪ Land use;</li> <li>▪ Topography</li> </ul>	Land use determines the capability of the area to recharge
	Industry	<ul style="list-style-type: none"> <li>▪ Water demand;</li> <li>▪ Flow of groundwater abstraction;</li> <li>▪ Industrial area</li> </ul>	making more wells, the abstracted water exceeds the permitted flow that causes permanent drops of the water table; reduce the recharge rate.
	Law and Regulation	<ul style="list-style-type: none"> <li>▪ Environmental law related to groundwater</li> </ul>	may safe the water
	Seawater	<ul style="list-style-type: none"> <li>▪ Intrusion far inland</li> </ul>	Seawater may intrude groundwater

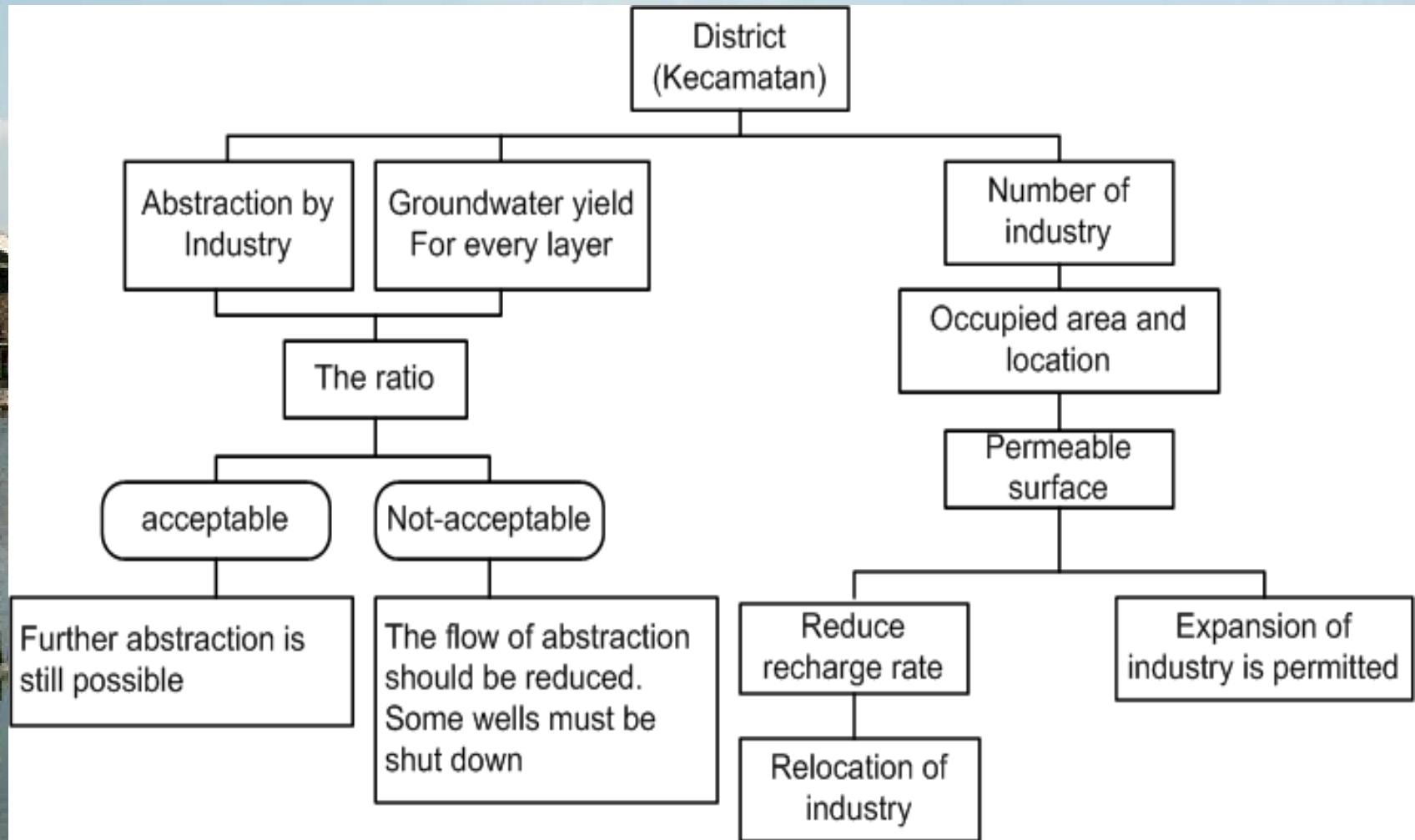
**The Direct Influence of the connected Components to Groundwater**

# The System Interrelationship Model of Groundwater in Cities

Component	Influential Components	Data	Explanation
Water supply company	Groundwater	<ul style="list-style-type: none"> <li>▪ Yield;</li> <li>▪ Depth of permeable layer;</li> <li>▪ Water quality</li> </ul>	Groundwater may become low price water source.
Recharge area			non
Industry			An area having high groundwater yield is preferred by investors
Law and Regulation			Bad situations requires law and regulations.
Seawater			non

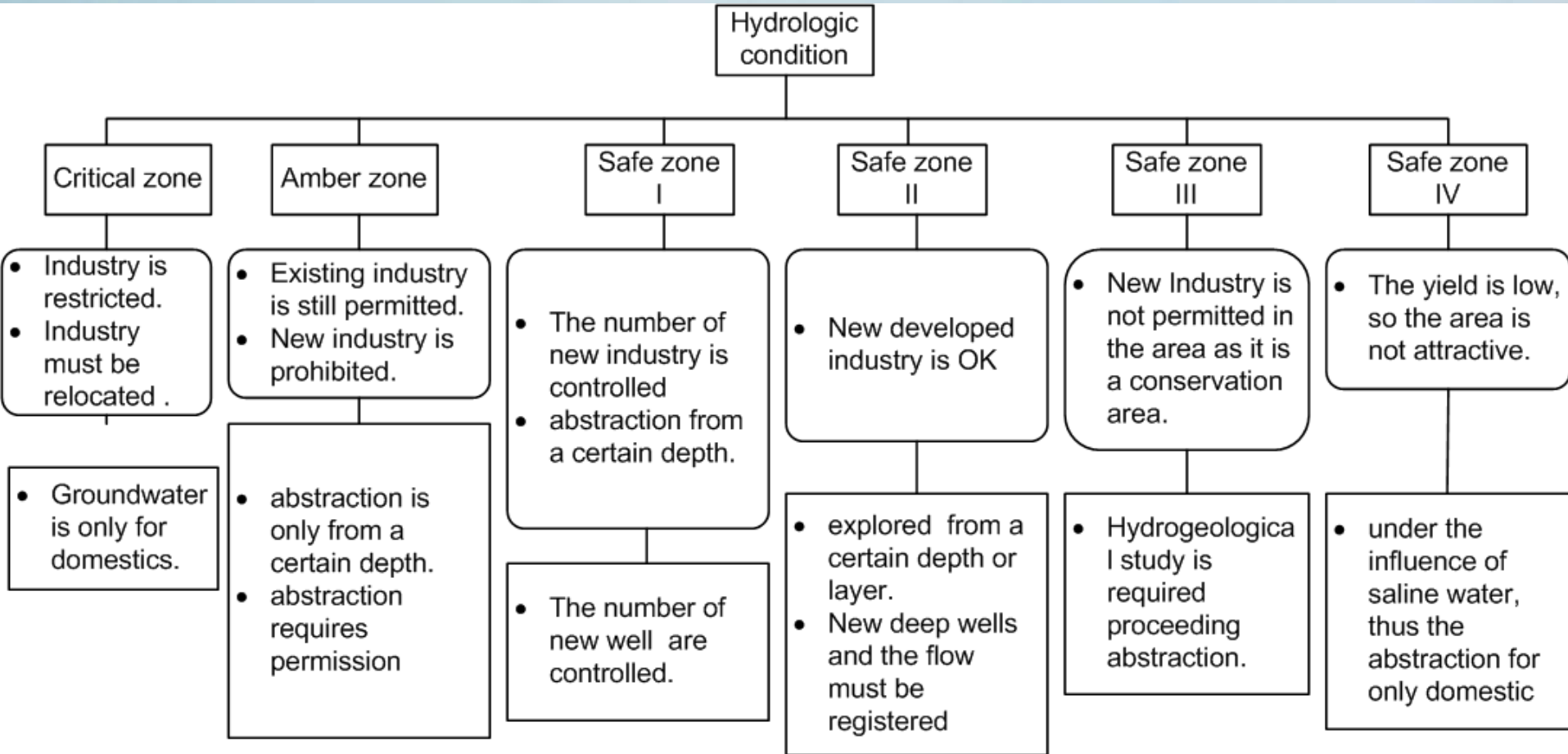
**The Direct Influence of Groundwater to the Connected Components**

# The System Interrelationship Model of Groundwater in Cities



**The influential of Industry to Groundwater**

# The System Interrelationship Model of Groundwater in Cities



## The Influential of Groundwater to Industry

# The Intervention

<b>Components</b>	<b>Intervention</b>
Wt supply co.	Raise the service for domestic and industry
Groundwater	Protection to over exploitation.
Seawater	Non.
Shallow groundwater	Shallow groundwater must be protected from wastewater,. Solid waste disposal is located in a right place.
Housing	Housing is not located in recharge areas. It is provided with wastewater treatment and solid waste collection and disposal facilities.
Agriculture	Agriculture practices should avoid erosion and minimal use of pesticide and fertilizer.
Recharge area	Recharge areas must be kept green.
Industry	Groundwater consumed by industries should be substituted. Otherwise individual mini-treatment is applied. communal wastewater treatment can be implemented to reduce cost and raise efficiency.
Surface water	Surface water should be protected
Law & reg	Law enforcement and control are required.

# Conclusion

- To manage groundwater in cities , we must take account on all **related components**, such as shallow GW, industry, recharge area, law and regulation, water supply company, surface water, agriculture, housing, and seawater
- We need to understand the **role of each component**
- The components are interrelated **in a System** Interrelationship Model
- Simultaneous '**intervention**' to the components is an integrated effort
- If the groundwater is maintained, it can **sustain life in the city**