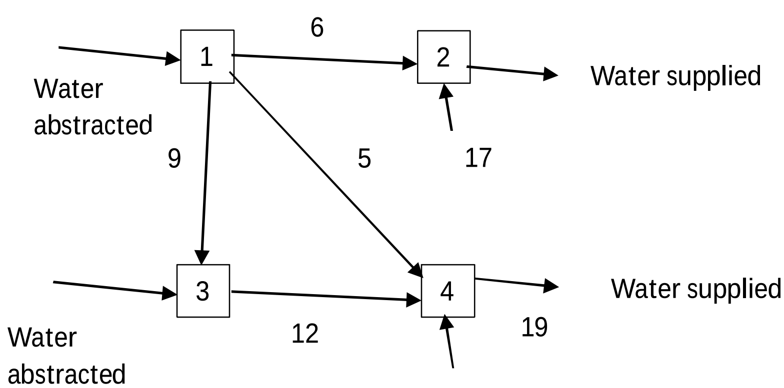
ICE BREAKER EXERCISE --- USE OF GRAPHS AND TABLES, SUPPLY AND USE TABLES

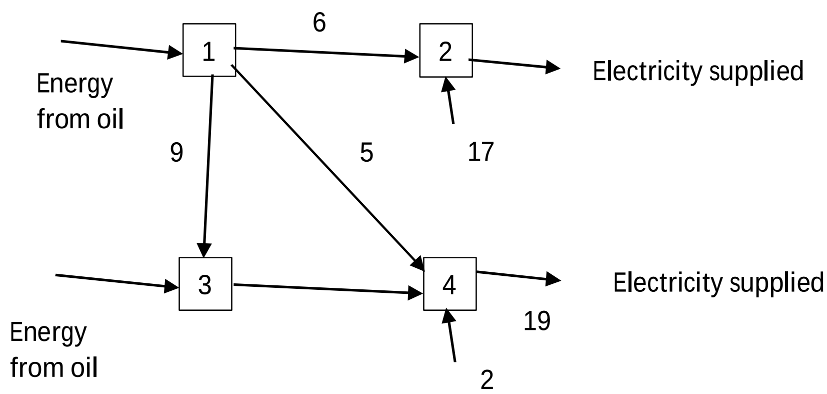
The group breaks into three smaller groups. Preferably, group 1 will have mainly people who know about water; group 2 people who know about energy, and group 3, people familiar with national accounts.

A. INFORMATION PROVIDED TO THE GROUPS

GROUP 1: "Water network"
The group is provided with the diagram shown below. The diagram shows a water supply network. Each arrow from one square to another represents a pipe. Each square represents a pumping station that pumps water (abstracts water) from a subjacent aquifer. The numbers indicate the amount of water flowing through the pipes. The flows are indicated in thousands of cubic meters per day (m^3/day). There are no losses in the system.
QUESTION: How much water is abstracted from the aquifers? Also, can you tell how much water is produced and how much water is produced at each pump?



GROUP 2: "Electric network" Flows in MW, no losses.
The group is provided with the diagram shown below. It is an interconnected electric network. Each arrow from one square to another represents a transmission line. The numbers indicate flows of energy in megawatts (MW). In each square there is plant that burns petroleum to produce electricity. There are no losses in the system.
QUESTION: How much electricity is produced? How much electricity is produced at each plant? How much energy is obtained from petroleum?



GROUP 3: "Transaction network" Flows in million Rupees (Rs) per year.
The group is provided with the information below about an economy made of four industries. All the units are in million Rupees (Rs) per year. There are no taxes or subsidies, nor imports or exports.
QUESTION: What is the GDP of the economy described? Can GDP be calculated in different ways?

Industry 1 produces 20 000 of product 1
Industry 2 produces 23 000 of product 2
Industry 3 produces 12 000 of product 3
Industry 4 produces 19 000 of product 4

Industry 1 does not use any product
Industry 2 uses 6 000 of product 1
Industry 3 uses 9 000 of product 1
Industry 4 uses 12 000 of product 3
Industry 4 uses 5 000 of product 1

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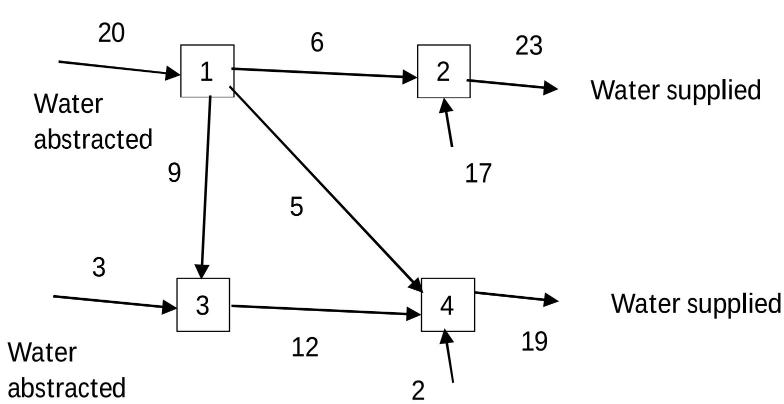
B. POSSIBLE "SOLUTIONS"

GROUP 1: "Water network" Flows in thousands of m^3/day, no losses
Equilibrated each node. Flows entering the node should be equal to flows leaving the node.



Total water abstracted = 20 + 17 + 3 + 2 = 42 thousand m^3/day (adding arrows entering network)
Total water produced = 23 + 19 = 42 thousand m^3/day (adding arrows leaving the network)
Total water produced at each pump =

Pump 1 = 9+6+5 = 20
Pump 2 = 23 – 6 (produced by 1) = 17
Pump 3 = 12 – 9 (produced by 1) = 3
Pump 4 = 19 – 5 (produced by 1) – 12 (produced by 3) = 2
The sum is 20+17+3+2 = 42 thousand m^3/day

GROUP 2: "Electric network" Flows in MW, no losses

Equilibrated each node. Same diagram as group one.

Total power generated = 42 MW.
Analogous to the problem of water it can be seen from the side of the arrows entering the system, from the side of the arrows leaving the system, or from what each unit adds to the system (without double counting).

MW are the flow units, MWh are the stock units. Flow units and stock units are used interchangeably depending on the context.
For example 42 MWh were generated in one hour (42MWh/h) is the same as a constant flow of 42 MW during one hour.

Flow units always have units of time in the denominator. Remember that 42 MW = 42 Joules/second.

GROUP 3: "Transaction network" Flows in thousands of million Rupees per year (billions in some countries, milliards in others)

SUPPLY	I1	I2	I3	I4	SUM
P1	20				**20**
P2		23			**23**
P3			12		**12**
P4				19	**19**
	20	**23**	**12**	**19**	**74**

SUPPLY = USE
20
23
12
19

USE	I1	I2	I3	I4	SUM	FINAL USE	SUPPLY = USE
P1		6	9	5	20	0	20
P2					0	23	23
P3				12	12	0	12
P4					0	19	19
	0	**6**	**9**	**17**	**32**		

VA	**20**	**17**	**3**	**2**	**42**

Gross Domestic Product (GDP) = 42 000 million Rupees per year.

GDP can be found in three different ways, analogous to what was done for group 1 and 2.

1. GDP = difference of supply sum less use sum = 74 – 32 = 42.
2. GDP = sum of final use = 23 + 19 = 42.
3. GDP = sum of value entering the system = 20+17+3+2 = 42.

Another way of expressing the quantities is as follows:

↑	I1	I2	I3	I4	OUT-SIDE	SUM
I1		6	9	5		**20**
I2					23	**23**
I3				12		**12**
I4					19	**19**
OUT-SIDE	20	17	3	2		
SUM	**20**	**23**	**12**	**19**		

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C. POSSIBLE "LESSONS"

1. The three groups got analogous "results" for completely different "problems." There are similarities.
2. Groups 1 and 2 used graphs, while group 3 used tables. Graphs and tables have advantages and disadvantages. Graphs are easier to understand, but get complicated when there are many nodes. Tables are more difficult to understand (more abstract), but are more compact and can be easily processed in a computer (e.g. spreadsheets)
3. Terminology is important to share results. The groups were not able to understand each other because the terms they were using had different meanings. Only national accountants had a standardized language.
4. Sometimes it is necessary to synthesize the complexity of the "networks" in one number. The magic number to express the complex arrangement of flows was 42!!!, which is useful (very compact) and also risky (may hide important details).
5. Group 3 could also derive other indicators about the network, such as intermediate consumption (32 billion Rs per year) or value added by each industry.

23 May 2013
Rev 3

DIGESTIF EXERCISE --- STOCKS AND FLOWS

A. INFORMATION PROVIDED TO THE GROUPS

Common question: what happens through time? What happens in two, three, four, ten years?

GROUP 1: "Water network"
The same information provided before (see ice-breaker exercise) plus the following:

Water is pumped from fossil aquifers (non-renewable water).

Pumping station 1 uses an aquifer that has 25 million cubic meters of water (hm^3)
Pumping station 2 uses an aquifer that has 70 million cubic meters of water (hm^3)
Pumping station 3 uses an aquifer that has 30 million cubic meters of water (hm^3)
Pumping station 4 uses an aquifer that has 10 million cubic meters of water (hm^3)

GROUP 2: "Electric network"
The same information provided before (see ice-breaker exercise) plus the following:

Electricity is produced from limited stocks of petroleum. 100 liters of petroleum generate 24 MWh

Plant 1 uses a limited stock of petroleum that originally has 25 hundred thousand liters
Plant 2 uses a limited stock of petroleum that originally has 70 hundred thousand liters
Plant 3 uses a limited stock of petroleum that originally has 30 hundred thousand liters
Plant 4 uses a limited stock of petroleum that originally has 10 hundred thousand liters

GROUP 3: "Transaction network"
The same information provided before (see ice-breaker exercise) plus the following:

Each product is produced with a special machine that:

For industry 1 has a consumption of fixed capital of 7.300 billion Rs per year.
For Industry 2 has a consumption of fixed capital of 6.205 billion Rs per year.
For Industry 2 has a consumption of fixed capital of 1.095 billion Rs per year.
For Industry 2 has a consumption of fixed capital of 0.730 billion Rs per year.

The initial value of the special machine of industry 1 is 25 000 billion Rs
The initial value of the special machine of industry 1 is 70 000 billion Rs
The initial value of the special machine of industry 1 is 30 000 billion Rs
The initial value of the special machine of industry 1 is 10 000 billion Rs

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B. POSSIBLE "SOLUTIONS"

GROUP 1: "Water network"

The analysis can be done simply by dividing 100 million cubic meters by 20 thousand cubic meters/day, which is 1250 days. This is 3.4 years. It is also possible to use tables, as shown below.

For the first year:

	Aquifer 1	Aquifer 2	Aquifer 3	Aquifer 4	Units
Opening stock of water	25	70	30	10	million cubic meters
Additions to stock					thousand cubic meters/day
Reductions in stock	20	17	3	2	thousand cubic meters/day
Closing stock of water					million cubic meters

The numbers cannot be added because they are in different units. The analysis can be done for each year, therefore the flow in thousands of cubic meters has to be converted into million cubic meters per year. We need to multiply the flows by 365 (days in a year) and divide by 1000 (to convert from thousands to millions).

For the first year:

	Aquifer 1	Aquifer 2	Aquifer 3	Aquifer 4	Units
Opening stock of water	25	70	30	10	million cubic meters
Additions to stock					million cubic meters
Reductions in stock	7.3	6.205	1.095	0.73	million cubic meters
Closing stock of water	17.7	63.795	28.905	9.27	million cubic meters

The second year:

	Aquifer 1	Aquifer 2	Aquifer 3	Aquifer 4	Units
Opening stock of water	17.7	63.795	28.905	9.27	million cubic meters
Additions to stock					million cubic meters
Reductions in stock	7.3	6.205	1.095	0.73	million cubic meters
Closing stock of water	10.4	57.59	27.81	8.54	million cubic meters

The third year:

	Aquifer 1	Aquifer 2	Aquifer 3	Aquifer 4	Units
Opening stock of water	10.4	57.59	27.81	8.54	million cubic meters
Additions to stock					million cubic meters
Reductions in stock	7.3	6.205	1.095	0.73	million cubic meters
Closing stock of water	3.1	51.385	26.715	7.81	million cubic meters

It can be seen that after the third year, only 3.1 million cubic meters of water are available in aquifer 1. Therefore it is not possible to keep the pumps operating the fourth year in the same way.

GROUP 2: "Electric network"

For the first year:

	Stock of oil 1	Stock of oil 2	Stock of oil 3	Stock of oil 4	Units
Opening stock of oil	25	70	30	10	hundreds of thousand liters of petroleum
Additions to stock					MW
Reductions in stock	20	17	3	2	MW
Closing stock of oil					hundreds of thousand liters of petroleum

The numbers cannot be added because they are in different units. The analysis can be done for each year, therefore the flows in MW have to be converted into liters of oil.

A flow of 1 MW is equivalent to a stock of 24 MWh in 24 hours (24 hours x 1 MW). Therefore, to maintain a generation of 1 MW of energy for one day (24 hours), 1 liter of oil is needed. In one year 365 liters of oil are needed to maintain a constant generation of power of 1 MW. The flows in the table above have to be converted into thousands of liters of oil by multiplying by 0.365 (times 365 days and divided by 1000 to have the numbers in thousands.

Therefore, the first year:

	Stock of oil 1	Stock of oil 2	Stock of oil 3	Stock of oil 4	Units
Opening stock of oil	25	70	30	10	hundreds of thousand liters of petroleum
Additions to stock					hundreds of thousand liters of petroleum
Reductions in stock	7.3	6.205	1.095	0.73	hundreds of thousand liters of petroleum
Closing stock of oil	17.7	63.795	28.905	9.27	hundreds of thousand liters of petroleum

The second year:

	Stock of oil 1	Stock of oil 2	Stock of oil 3	Stock of oil 4	Units
Opening stock of oil	17.7	63.795	28.905	9.27	hundreds of thousand liters of petroleum
Additions to stock					hundreds of thousand liters of petroleum
Reductions in stock	7.3	6.205	1.095	0.73	hundreds of thousand liters of petroleum
Closing stock of oil	10.4	57.59	27.81	8.54	hundreds of thousand liters of petroleum

The third year:

	Stock of oil 1	Stock of oil 2	Stock of oil 3	Stock of oil 4	Units
Opening stock of oil	10.4	57.59	27.81	8.54	hundreds of thousand liters of petroleum
Additions to stock					hundreds of thousand liters of petroleum
Reductions in stock	7.3	6.205	1.095	0.73	hundreds of thousand liters of petroleum
Closing stock of oil	3.1	51.385	26.715	7.81	hundreds of thousand liters of petroleum

GROUP 3: "Transaction network"

For the first year

	Fixed capital 1	Fixed capital 2	Fixed capital 3	Fixed capital 4	Units
Opening stock of fixed capital	25	70	30	10	billion Rs
Additions to stock					billion Rs per year
Reductions in stock	7.3	6.205	1.095	0.73	billion Rs per year
Closing stock of fixed capital	?	?	?	?	billion Rs

The numbers cannot be added because they are in different units. The analysis can be done for each year, therefore the flows in billion Rs per year should be converted into billion Rs.

This is very simple, since 1 billion Rs per year for one year = 1 billion Rs. Therefore the numbers simply have to be multiplied by one (1/year), to convert the flows into stocks.

Therefore, the first year:

	Fixed capital 1	Fixed capital 2	Fixed capital 3	Fixed capital 4	Units
Opening stock of fixed capital	25	70	30	10	billion Rs
Additions to stock					billion Rs
Reductions in stock	7.3	6.205	1.095	0.73	billion Rs
Closing stock of fixed capital	17.7	63.795	28.905	9.27	billion Rs

The second year:

	Fixed capital 1	Fixed capital 2	Fixed capital 3	Fixed capital 4	Units
Opening stock of fixed capital	17.7	63.795	28.905	9.27	billion Rs
Additions to stock					billion Rs
Reductions in stock	7.3	6.205	1.095	0.73	billion Rs
Closing stock of fixed capital	10.4	57.59	27.81	8.54	billion Rs

The third year:

	Fixed capital 1	Fixed capital 2	Fixed capital 3	Fixed capital 4	Units
Opening stock of fixed capital	10.4	57.59	27.81	8.54	billion Rs
Additions to stock					billion Rs
Reductions in stock	7.3	6.205	1.095	0.73	billion Rs
Closing stock of fixed capital	3.1	51.385	26.715	7.81	billion Rs

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C. POSSIBLE "LESSONS"

1. The three groups got analogous "results" for completely different "problems." There are similarities. In the first 3 years nothing really changed.
2. However, it was clear that after 3 years and a half things would change. The fossil aquifer would be completely depleted, the stock of oil also. The special machine for industry 1 would be unable to generate products and would have no value.
3. Groups 1 and 2 most likely did the calculations in a free format to get the same results as group 3. Group 3 had a standardized format and generated a table that was understood by all the group. The standardized tables are useful for sharing the results.

Solutions to the “stock-flow-network” exercise

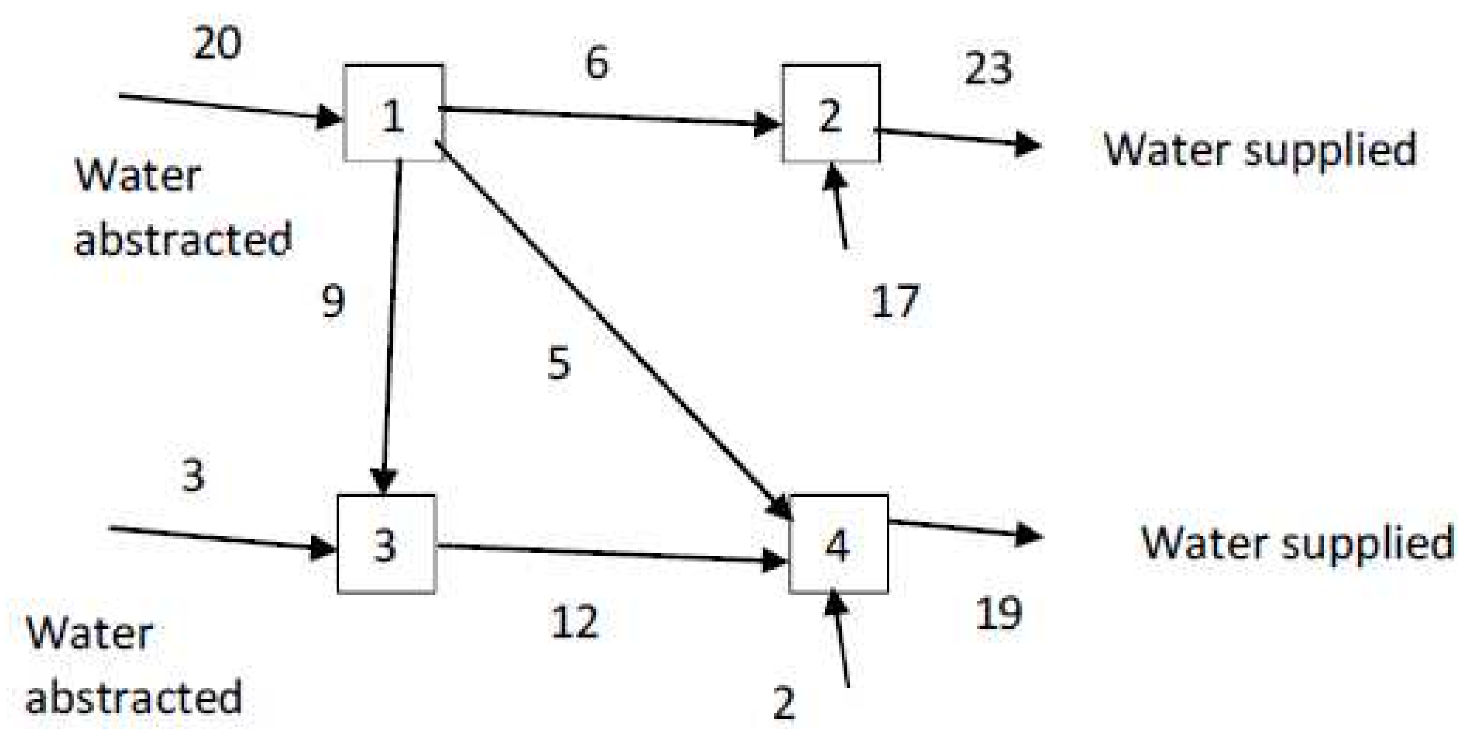
UN Statistics Division

2 June 2013

Structure

“spatial slicing”

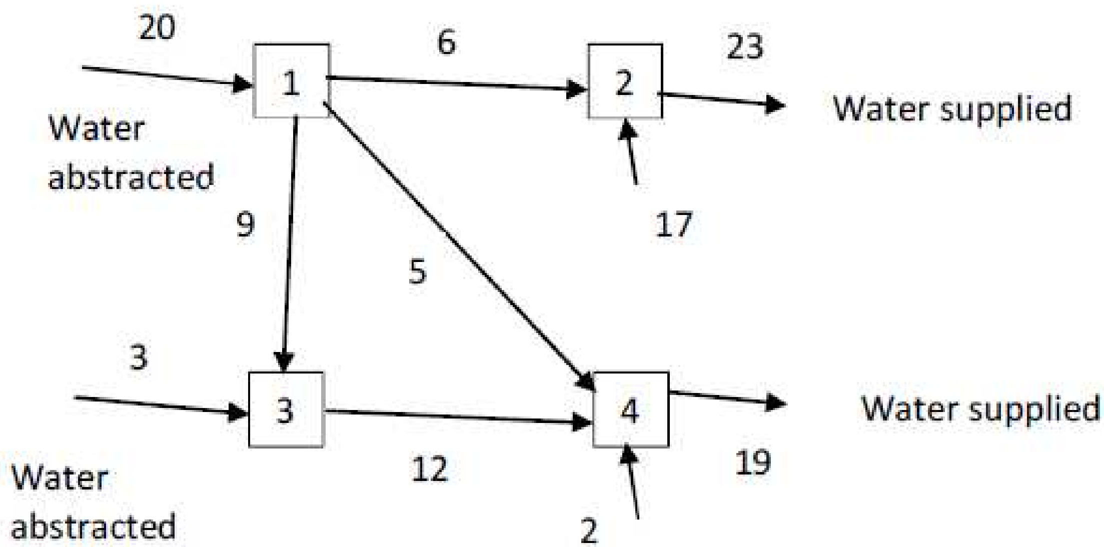
Graph of network.



There is equilibrium in each node. Amount of water entering each node = amount of water leaving each node.

Some indicators:

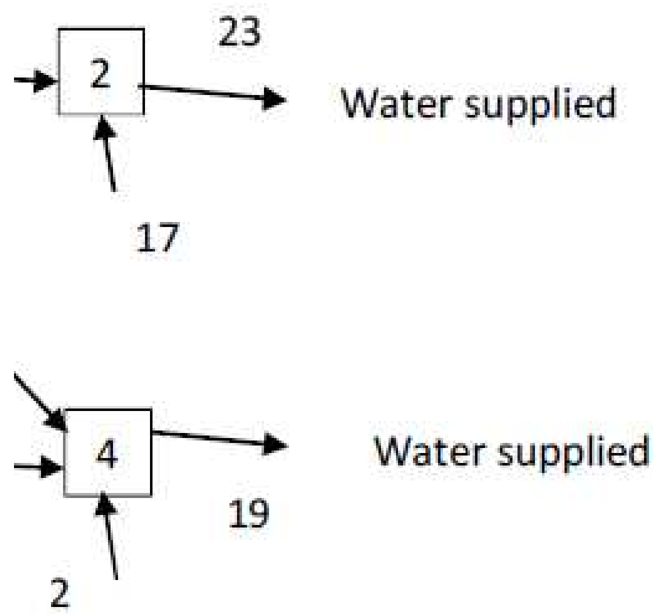
- Water supplied: 23 + 19 = 42 thousand m3/day
- Water abstracted: 20 + 3 + 17 + 2 = 42 th. m3/day
- Water "produced" at each pumping station =
  20 + (12-9) + (23-6) + (19-17) = 42



There are three indicators, or three ways of calculating the same indicator.

First calculation

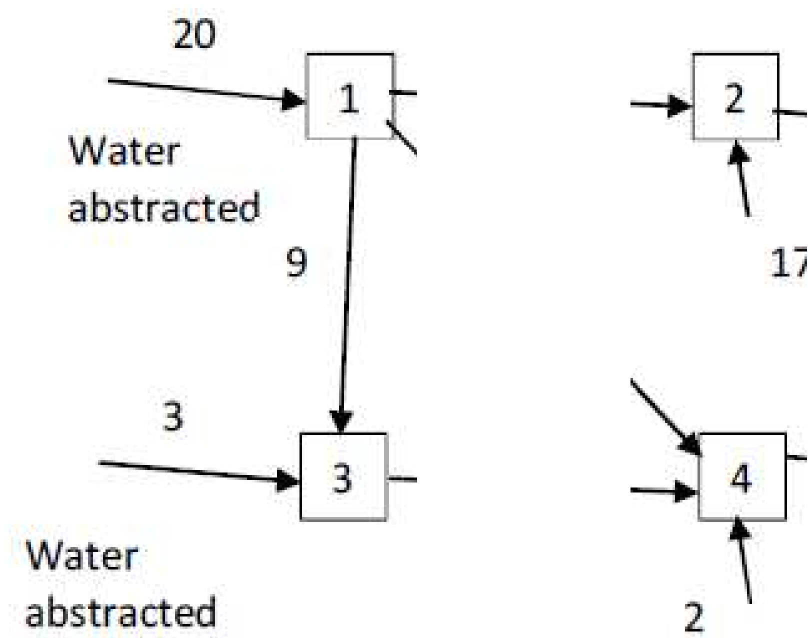
- **Water supplied:** **23 + 19 = 42 thousand m3/day**



Sum or aggregation of the amount of water provided by the system or network.

Second calculation:

- **Water abstracted:** **20 + 3 + 17 + 2 = 42 th. m3/day**

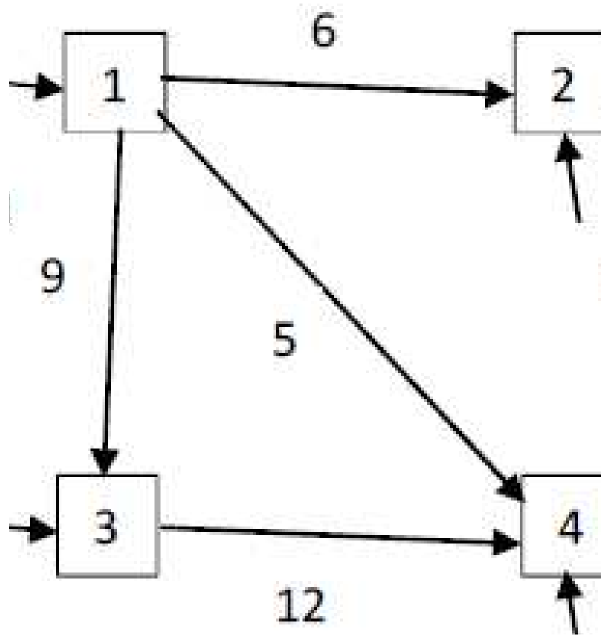


Sum or aggregation of water entering the system or network.

Third calculation:

- Water "produced" at each pumping station =

  20 + (12-9) + (23-6) + (19-17) = 42



There are three indicators, or three ways of calculating the same indicator.

Representation with tables:

SUPPLY	I1	I2	I3	I4	SUM
P1	20				**20**
P2		23			**23**
P3			12		**12**
P4				19	**19**
	20	**23**	**12**	**19**	**74**

SUPPLY = USE
20
23
12
19

USE	I1	I2	I3	I4	SUM	FINAL USE	SUPPLY = USE
P1		6	9	5	20	0	20
P2					0	23	23
P3				12	12	0	12
P4					0	19	19
	0	**6**	**9**	**17**	**32**		

VA	**20**	**17**	**3**	**2**	**42**

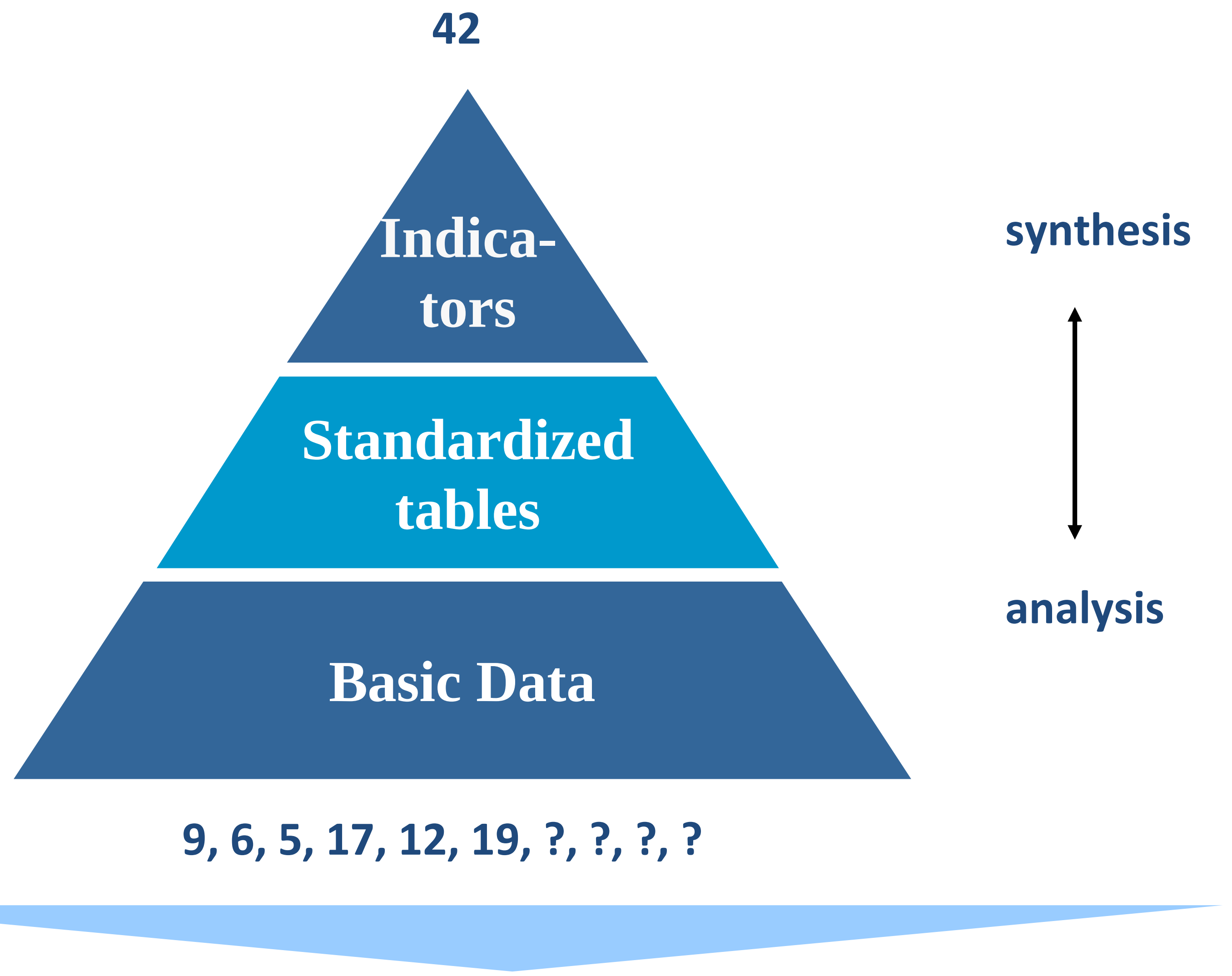
The tables show the total amounts produced at each node (supply table) and the total amounts consumed at each node.

Representation with tables. Input - output

	I1	I2	I3	I4	OUT-SIDE	SUM
I1		6	9	5		20
I2					23	23
I3				12		12
I4					19	19
OUT-SIDE	20	17	3	2		
SUM	20	23	12	19		

Tables show the value flows between nodes.

Synthesis of data

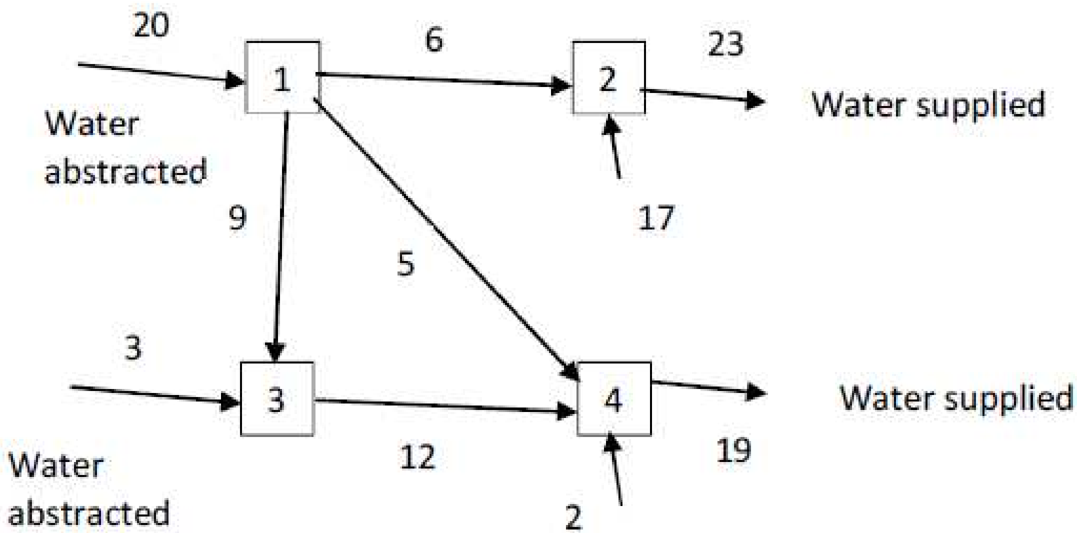


Several data items are "represented" by a single number. Missing data "?" was found. Data was organized with supply and use tables.

Dynamics

“time slicing”

Abstractions (“flows”) come from (“stocks”)



For the first year:

	Aquifer 1	Aquifer 2	Aquifer 3	Aquifer 4	Units
Opening stock of water	25	70	30	10	million cubic meters
Additions to stock					thousand cubic meters/day
Reductions in stock	20	17	3	2	thousand cubic meters/day
Closing stock of water					million cubic meters

Each year (or time cycle) the “stock” of water will be reduced. Need to work with the same units.

For the first year:

	Aquifer 1	Aquifer 2	Aquifer 3	Aquifer 4	Units
Opening stock of water	25	70	30	10	million cubic meters
Additions to stock					million cubic meters
Reductions in stock	7.3	6.205	1.095	0.73	million cubic meters
Closing stock of water	17.7	63.795	28.905	9.27	million cubic meters

The second year:

	Aquifer 1	Aquifer 2	Aquifer 3	Aquifer 4	Units
Opening stock of water	17.7	63.795	28.905	9.27	million cubic meters
Additions to stock					million cubic meters
Reductions in stock	7.3	6.205	1.095	0.73	million cubic meters
Closing stock of water	10.4	57.59	27.81	8.54	million cubic meters

The third year:

	Aquifer 1	Aquifer 2	Aquifer 3	Aquifer 4	Units
Opening stock of water	10.4	57.59	27.81	8.54	million cubic meters
Additions to stock					million cubic meters
Reductions in stock	7.3	6.205	1.095	0.73	million cubic meters
Closing stock of water	3.1	51.385	26.715	7.81	million cubic meters

There are changes through time

Motion is captured by a set of images taken in a period of time.