Systems Thinking

Objective

Modern science has been heavily influenced by 18th century mechanistic or reductionist thinking, emphasizing the ability to understand the whole in a "machine-like" or mechanistic way by a detailed understanding of its parts. However, the events we study on a day-to-day basis are inevitably outgrowths of complex interactions within geological, biological, and social systems, or combinations thereof – hence a systems thinking approach.

Mechanistic Thinking	Systemic Thinking
Parts	Wholes
Objects	Relationships
Events	Structures
Isolation	Interdependence
Specificity	Generality
Simplicity	Complexity

Table 1
Mechanistic thinking versus systemic thinking

In this activity, you will be introduced to the idea that by developing a deeper understanding about the underlying structure of social and environmental issues (i.e., by taking a systems perspective), we can begin to intervene strategically to influence the system as a whole to solve global challenges.

Introduction to Systems Thinking - What is a System?

- "An interconnected set of elements that is coherently organized around some purpose" - *Dana Meadows*
- "Integrated wholes whose properties cannot be reduced to those of smaller units" - *Fritjof Capra*
- “A system is an entity which maintains its existence through the mutual interaction of its parts.” - *Gene Bellinger*

What is Systems Thinking?

- "Seeing interconnectedness and relationships, the whole picture as well as the component parts" - *Gunter Ossimitz*
- "A discipline for seeing wholes...a framework for seeing interrelationships rather than things, for seeing patterns rather than static snapshots" - *Peter Senge*
- “The key emphasis here is one of "mutual interaction," in that something is occurring between the parts, over time, which maintains the system.” - *Gene Bellinger*

Systems thinking is a recent approach in science emphasizing deeper understanding, inter-connectedness and dependence of parts of the systems as opposed to the mechanistic way of looking at distinct parts to understand the whole. Systems thinking allows us to understand how systemic structures lead to patterns and events. For example an increase in atmospheric CO_2 concentration (systemic structure) from fossil fuel combustion may give us a pattern of increased global temperatures (pattern). This in turn may create events and cause sea-level rise or increased severe weather (event).

How is Systems Thinking Useful?

- Helps capture complex systems and relationships that are hard to keep track of and understand.

- From the mutual interaction of the parts of a system there arise characteristics, which cannot be found as characteristic of any of the individual parts. Systems thinking facilitates understanding of these emergent properties.
- Gives us a basis for quantifying and decision-making.
- Allows us to think about solutions via leverage points or changing flows/variables.

New York City Garbage Example
To better understand what we mean by systems thinking let's use the garbage sanitation system in New York as an example. This system contains a Population (P), Garbage (G), Bacteria (B), Disease (D), Sanitation Facilities (S), Modernization (M) and City Migration (C). Look at the green loop (Figure 1).

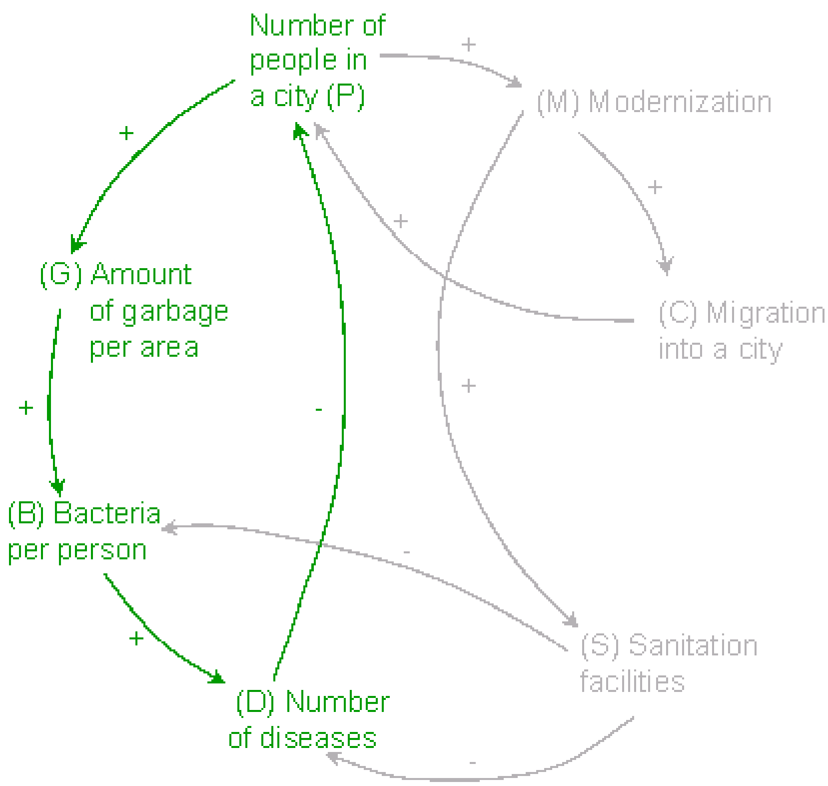

Figure 1
Green loop of NYC garbage systems thinking diagram

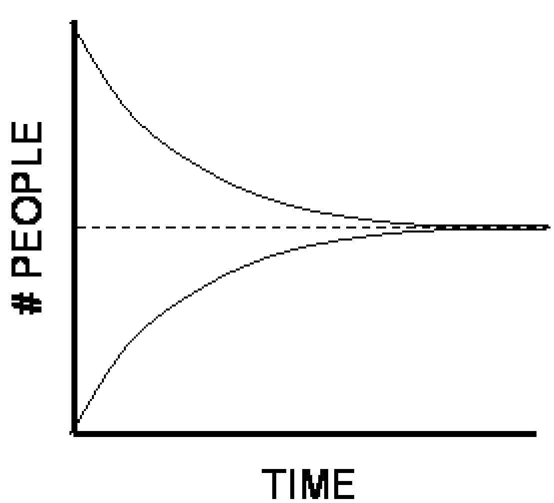

Figure 2
Population dynamics of a balancing (or negative) loop

It is often useful in systems thinking to talk your self through the system. First choose a direction (increase or decrease) and a logical starting point for the green loop. Population (P) is a good place to start.

- If the number of people (P) in a city increases then the amount of garbage (G) they produce will increase. Therefore this arrow has a + associated with it. (This would also be the case if you chose for initial population to decrease.)
- As the amount of garbage (G) increases, the amount of bacteria (B) per person also increases. Thus, this section of the loop also has a + sign associated with it.
- As the amount of Bacteria (B) increases, the number of diseases (D) will increase. Again, a positive relationship.
- As the number of diseases (D) increases, the number of people dying from disease will increase and this willdecrease the population. This relationship is opposite or negative (increase in disease = decrease in population) thus, a – sign is associated with it.
- To determine a balancing loop from a reinforcing loop, count the number of minus signs around the loop.
  If there is an **even number, or zero, minus signs then it is a reinforcing (or positive) loop**.
  If there is an **odd number of minus-signs, then it's a balancing (or negative) loop**.
- By counting up the number of minus signs in this loop, we determine that there are an odd number of minus signs (1). Therefore, this must be a balancing loop. A balancing loop is one in which action attempts to bring two things to balance. Any situation where one attempts to solve a problem or achieve an objective is representative of a balancing loop. A balancing loop moves toward a goal such as moving toward a carrying capacity (Figure 2).

Let's look at another loop within the NYC garbage system. First choose a direction and a logical starting point for the pink loop (Figure 3).

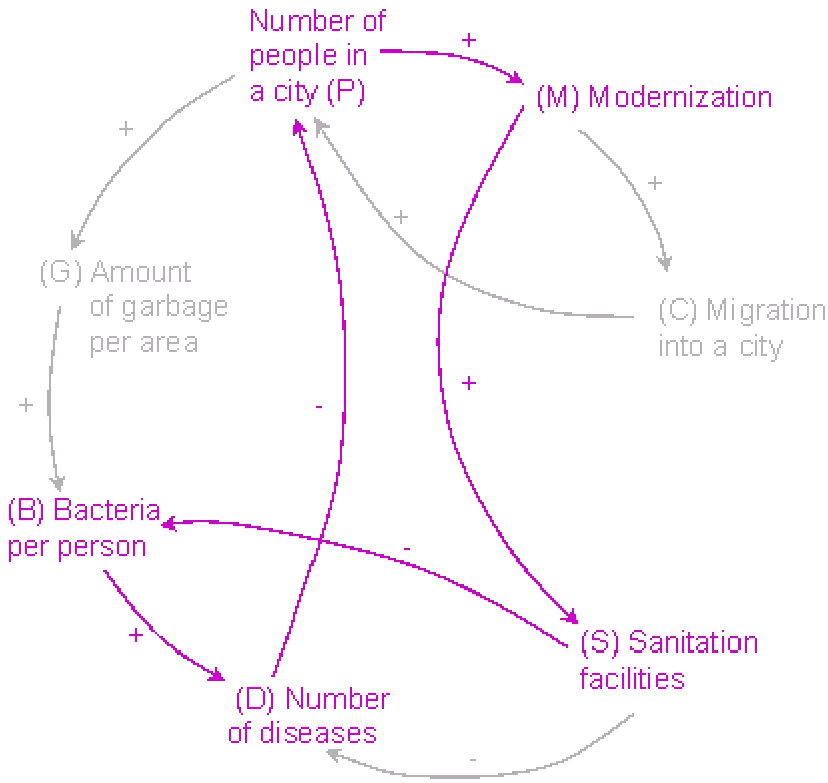

Figure 3
Pink loop of NYC garbage systems thinking diagram

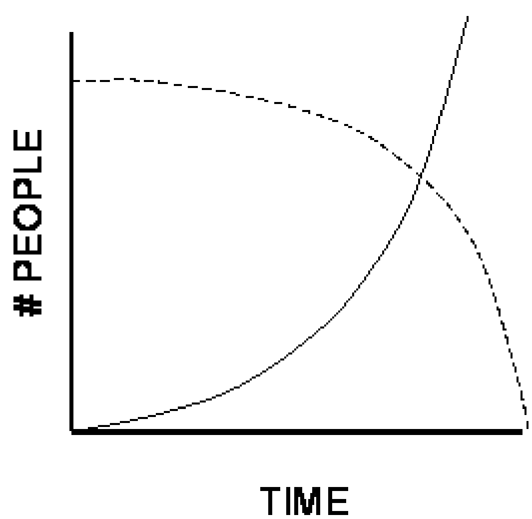

Figure 4
Population dynamics of a reinforcing (or positive) loop – exponential growth or decline

- If the number of people (P) in NY City increases then modernization (M) of the city will also increase. Therefore this arrow has a + associated with it.
- As modernization (M) increases, the sanitation facilities (S) will also increase. Thus, this section of the loop also has a + sign associated with it.
- As sanitation (S) increases, the number of bacteria (B) will decrease. Therefore, this part of the loop has a negative relationship.
- As the number of bacteria (B) decreases, the number of diseases (D) will also <u>decrease</u>. This is where systems thinking becomes complicated. Although the

numbers of diseases are decreasing your relationship between bacteria and disease is positive. More bacteria = more disease or less bacteria = less disease. Both of these relationships go in the same direction so the relationship is positive.

- When the number of diseases (D) decreases, people dying from disease will also decrease and this will <u>increase</u> the population. This relationship is negative thus, a – sign is associated with it.
- By counting up the number of minus signs in this loop, we determine that there is an even number of minus signs (2). Therefore, this must be a reinforcing loop. A reinforcing loop is one in which the interactions are such that each action adds to the other. Any situation where action produces a result, which promotes more of the same action, is representative of a reinforcing loop. A reinforcing loop promotes change with even more change; leads to exponential growth or decline (Figure 4).

Now that you are familiar with both the balancing and reinforcing loops, walk yourself through the other two loops in the system (Figure 5 and Figure 6). What kind of loops are they?

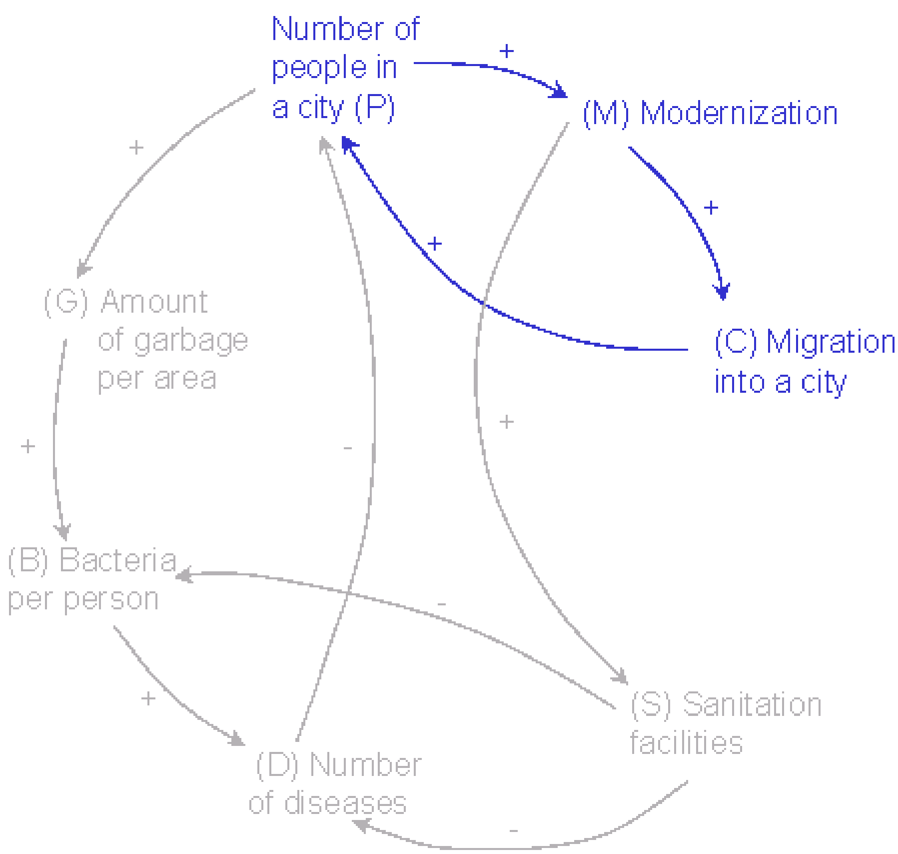

Figure 5
Blue loop of NYC garbage systems thinking diagram

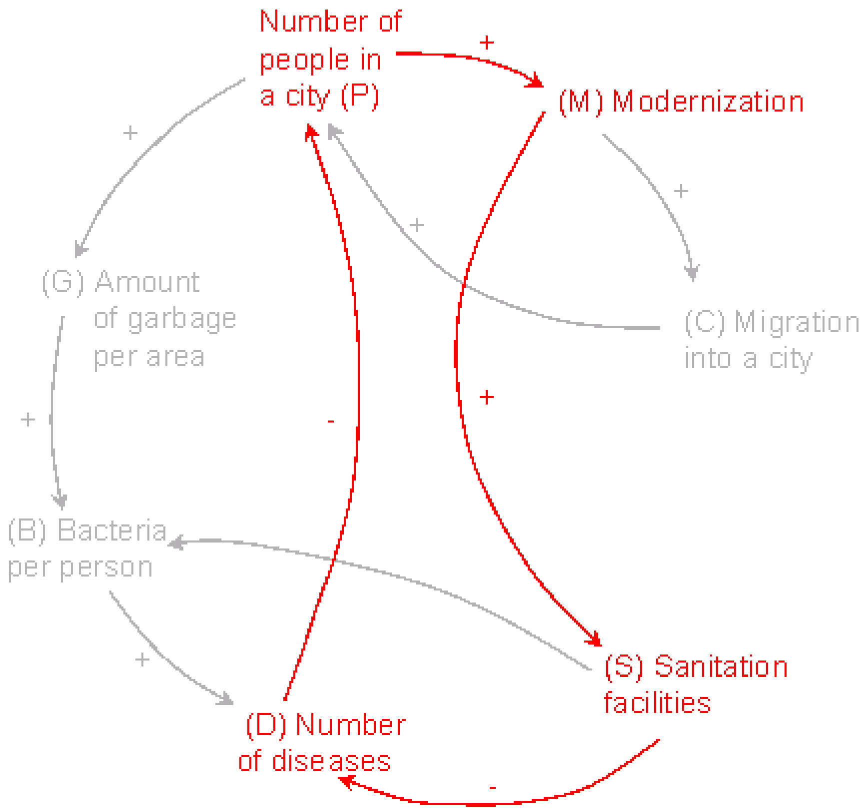

Figure 6
Red loop of NYC garbage systems thinking diagram

Sources

http://www.systems-thinking.org/intst/int.htm
http://www.slideshare.net/RajuMandhyan/systems-thinking-with-peter-senge-raju-mandhyan