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One System Affects All: Uncovering dynamic relationships across SDGs 11, 14 & 15

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One System Affects All: Uncovering dynamic relationships across SDGs 11, 14 & 15

Mamta Gautam and Sneha Thakur

As we enter the VUCA world,[1] the complexity is growing exponentially. It is often difficult to comprehend the root cause of unintended consequences one encounters and experiences when working with a complex system. With the growing nature of complexity, being able to map each component and understand each relation is overwhelming, time-consuming and maybe even counterproductive. This visual presentation demonstrates findings of integrating the basic principle of dynamic modelling into systems maps and modelling. Through this paper, the authors seek to state the case of using the positive (+) and negative relationships (-) in the map and discuss its advantages when applied to the UN Sustainable Development Goals (SDGs) and desired behaviours.

Using the concepts of '(+)' and '(–)' in the mapping, the students could establish the nature of dependency and clearly articulate the challenges the existing systems face. This was found to be effective in understanding the behaviour of the system. This presentation is an outcome of a systemic design course conducted at the National Institute of Design Haryana (NID), consisting of a deep dive into SDG localisation. As a project brief, the SDGs were organised into clusters of three correlated themes. As it is often difficult to address all the SDGs, the clustering of themes was indeed insightful in understanding the larger negative and positive relationships that co-exist and keep the system in play.

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[1] VUCA is volatility, uncertainty, complexity, and ambiguity

KEYWORDS: SDG11, SDG14, SDG15, mapping, modelling, system dynamics, biodiversity

RSD TOPICS: Learning & Education, Mapping & Modelling, Socioecological Design

Introduction

Based on the *Sustainable Development Goals Report 2021,* industrial design students at the National Institute of Design Haryana were given a project brief on localisation of SDGs. The project brief was to identify opportunity areas and propose a systemic design. The current exhibit focuses on the initial phase of understanding sustainable development goals (SDGs) as an interconnected network of systems, their influence, and their impact on each other and arriving at a problem central to the desired behaviour. This paper discusses the mapping process and considers its efficacy as a tool from the point of view of the mentor and the student. The design solution arrived at from the analysis presented through the exhibit is outside the purview of this presentation.

Project: Localisation of SDGs

Background

The United Nations (2015) Development Agenda for 2030, *Transforming Our World: The 2030 Agenda for Sustainable Development*, comprising 17 SDGs and 169 related targets, was adopted and signed by the Government of India in September 2015. Localisation of SDGs is crucial to any strategy aimed at achieving the goals under the 2030 Agenda. This involves adapting, planning, implementing, and monitoring the SDGs from national to local levels by relevant institutions and stakeholders.

Goals in this cluster:

- Goal 11. Make cities and human settlements inclusive, safe, resilient, and sustainable
- Goal 14. Conserve and sustainably use the oceans, seas, and marine resources for sustainable development

- Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and biodiversity loss.

Exhibit description

Diagram 1: Discovering (+) and (-) relationships across SDGs 11, 14 and 15.

Step 1: Identify the theme cluster from the given themes as a project brief. SDG 11, 14 and 15 formed a cluster, which has been taken up as the case for this presentation.

Step 2: Each SDG 11 of Human settlements, SDG 14 marine ecosystems, and SDG 15 terrestrial systems were taken up as the three key systems interacting to provide the “purpose=” food production for human consumption. Food production is the purpose, objective function or the objective which becomes the reference to understand the flow of energy, activity and behaviour.

Step 3: SDG11 (Human Settlement) as a system was further understood with the help of mapping its sub-systems.

For example:-

- sub system=Cities
- subsystem=Villages
- subsystem=Tribal villages
- subsystem=Hilly area settlement

Step 4: The above step is carried out for SDG 14 Marine Ecosystems as well as SDG15 Terrestrial Systems. Like a Venn diagram, the smaller components inside show the subsystems that are a part of the bigger system.

Step 5: After mapping the above sub-systems, the next layer of sub-sub systems was mapped. For example:

- Within the subsystem of villages
- Sub-subsystem=Plantation
- Sub-subsystem=Animal sheds
- Sub-subsystem=Dairy farms
- Sub-subsystem=Breeding farms

Step 6: Causal loops are completed across the hierarchy of sub and sub-systems

Step 7: With sub and sub-subsystem components mapped, their corresponding relationships are understood as '+', denoting they complement the function or form a reinforcing loop and '-' for balancing or negative relationships with each other.

Step 8: Stakeholders are mapped within each system. This was done to make sense of the complex relationships that co-exist. Subsequently, based on this understanding, a problem area was identified for framing and defining the system's boundary; in this case, it is eutrophication elimination.

Diagram 2: Framing the system

Step 1: Selecting the area for intervention was based on the localisation of the problem, which was situated in the state of Haryana. Agriculture and freshwater ecosystems were taken as the system to focus on eutrophication.

Step 2: Components were drawn from Diagram 1.

Step 3: Important positive and negative relationships were shown with (+) and (-) denotations to retain the dynamic nature of relationships.

Diagram 3: Unintended Eutrophication and its consequences

Step 1: With a focus on the system boundary, the key components are drawn from Diagram 2.

Step 2: All the systems are concentrated around the concept of eutrophication, its causes, its effects, and its stakeholders.

Step 3: Each system has a separate set of stakeholders mentioned outside the circle.

Step 4: The challenges and their root causes are also mentioned outside each component, as every system has its own set of challenges relating to eutrophication.

Step 5: Causal loops are completed across the sub-systems.

Step 6: The (+) and (-) signs denote the relationship between two components.

How to read the exhibit:

- Black Dotted lines show overlapping components
- The red lines show the causal loops
- (+) denotes reinforcing loop
- (-) denoted balancing loop
- Each diagram has colour coding across its sub-systems.
- As analysed, important information, behaviour, and symptoms are written along with their function to ensure the behaviour and relationship are easily understood.
- Research: Secondary research was used to validate the relationships.

Intentions and concept

Per the previous practice, the system mapping uses the cause-and-effect arrow, called a causal loop, to establish the connection. While this helps establish interdependencies, its dynamic nature is often missed in this approach. Through this paper, the author seeks to state the case of combining different causal models of systems (Barbrook-Johnson, 2022) methods:

1. Causal Loop: The students could use the same as a guiding star by integrating the positive and negative relationships into the systems map.
2. System Dynamics Modelling: The '+' and '–'are borrowed from systems dynamic modelling. The students were able to establish the nature of dependency. Since the focus was to understand relationships and retain simplicity, stock and flow, delays would have been cumbersome and hence avoided.
3. Fuzzy Cognitive Mapping: While the causal loop is limited in looking at one phenomenon, the same was overcome using fuzzy cognitive mapping (Barbrook-Johnson, 2022). Three SDGs were mapped, and relationships were established across the system, sub-system and sub-sub-system hierarchy.

Creative process

A macro-to-micro lens analysis was done initially by considering the ecosystem (Diagram 1), then becoming specific to India and the state of Haryana. The concept of eutrophication is prevalent in Haryana due to the excessive use of fertilisers in the nearby agricultural lands. Hence, it has become an interesting area of research for the project.

After framing the system (Diagram 2), the student tried to map out the system in detail (Diagram 3), with all the subsystems and elements involved. The aim was to represent the systems affected in different ways by Eutrophication and clearly articulate the stakeholders and key challenges for all of them. This helped determine the pain points in the project ahead. Denoting the negative relationships of eutrophication with other elements like fertiliser runoff, deforestation, soil quality, etc., through red allows with negative (-) sign signified all the key causes of the respective challenges mentioned next to the diagram.

Creating the systemic mapping diagram for this project was quite a journey. Initially, it felt like trying to solve a puzzle without all the pieces due to the complexities of understanding and drafting the relationships between different elements, sub-systems and systems. What was once a confusing mesh of connections started to make more sense with each step. Progressing into each next step brought more clarity on how one can start drafting the systemic map and focus on a specific portion while ensuring nothing is left out. Despite the clarity gained, the entire diagram still held a level of complexity. However, with multiple iterations, it gradually became more manageable. This was challenging yet invigorating and helped push our boundaries as industrial design students.

Reflection, insights and key findings

As it is often difficult to address all the SDGs, the clustering of themes was indeed insightful in understanding the larger negative and positive relationships that co-exist and keep the system in play. The relationships, when understood for three levels of sub-systems, with their unintended consequences mapped as a function, make clear what must *not* be done.

In this systemic mapping, the positive and negative labelling of relationships of the balancing and reinforcing loops between subsystems and their elements helped the student gain perspective about the SDGs. It was easier to comprehend the impact that one element may have on another and highlight portions that could be framed together due to their direct or inverse relationships. To dissolve the conditions leading to unintended consequences, the positive (+) and negative (-) relationships helped us understand the SDGs in a new light.

Conclusion

The module on system thinking has thrown light on the importance of understanding the unknown consequences when the SDGs were taken up as a project brief. Though extensive, time-consuming, and overwhelming to map and denote the relationships manually, the nature of the problem identified is unique and supported with analysis. Contrary to this, with only the 'causal 'arrows, one only understands the connection, but the nature of the relationship is missed. The students found the choice of Kumu software for mapping to be more expressive.

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Secondary research

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https://haryanaforest.gov.in/

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https://commerce.gov.in/about-us/autonomous-bodies/the-marine-products-export-development-authority-mpeda/

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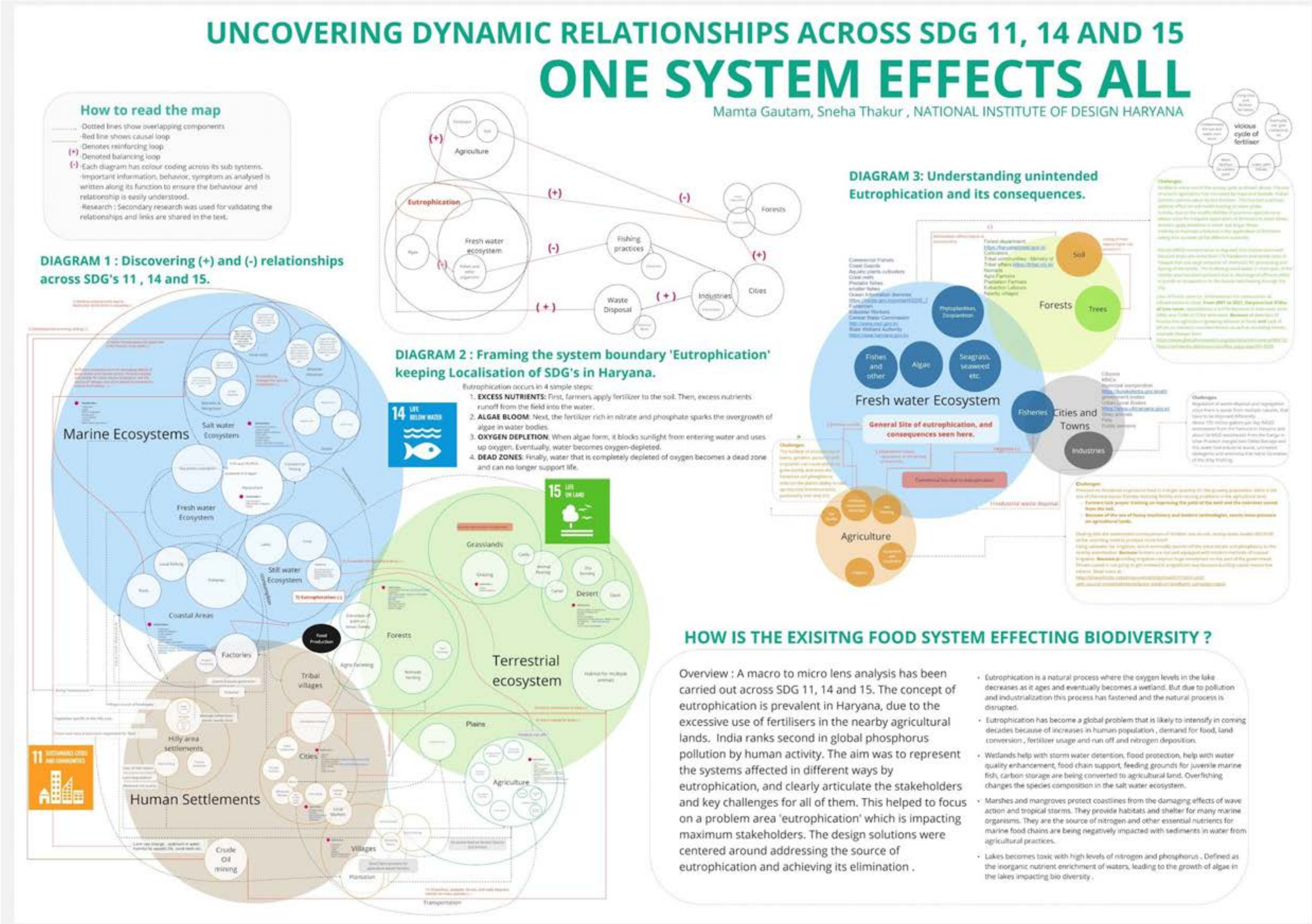
UNCOVERING DYNAMIC RELATIONSHIPS ACROSS SDG 11, 14 AND 15
ONE SYSTEM EFFECTS ALL
Mamta Gautam, Sneha Thakur , NATIONAL INSTITUTE OF DESIGN HARYANA
How to read the map
·Dotted lines show overlapping components
·Red line shows causal loop
·Denotes reinforcing loop
(+) ·Denoted balancing loop
(-) ·Each diagram has colour coding across its sub systems.
·Important information, behavior, symptom as analysed is written along its function to ensure the behaviour and relationship is easily understood.
·Research : Secondary research was used for validating the relationships and links are shared in the text.
DIAGRAM 1 : Discovering (+) and (-) relationships across SDG's 11 , 14 and 15.
Marine Ecosystems
Salt water Ecosystem
Fresh water Ecosystem
Still water Ecosystem
Coastal Areas
Factories
Tribal villages
Hilly area settlements
Cities
Human Settlements
Crude Oil mining
Villages
Plantation
Forests
Terrestrial ecosystem
Grasslands
Desert
Plains
Agriculture
Agriculture
Eutrophication
Fresh water ecosystem
Fishing practices
Forests
Waste Disposal
Industries
Cities
(+)
(-)
DIAGRAM 2 : Framing the system boundary 'Eutrophication' keeping Localisation of SDG's in Haryana.
Eutrophication occurs in 4 simple steps:
1. EXCESS NUTRIENTS: First, farmers apply fertilizer to the soil. Then, excess nutrients runoff from the field into the water.
2. ALGAE BLOOM: Next, the fertilizer rich in nitrate and phosphate sparks the overgrowth of algae in water bodies.
3. OXYGEN DEPLETION: When algae form, it blocks sunlight from entering water and uses up oxygen. Eventually, water becomes oxygen-depleted.
4. DEAD ZONES: Finally, water that is completely depleted of oxygen becomes a dead zone and can no longer support life.
14 LIFE BELOW WATER
15 LIFE ON LAND
11 SUSTAINABLE CITIES AND COMMUNITIES
DIAGRAM 3: Understanding unintended Eutrophication and its consequences.
vicious cycle of fertiliser
Soil
Forests
Trees
Phytoplankton, Zooplankton
Fishes and other
Algae
Seagrass, seaweed etc.
Fresh water Ecosystem
Fisheries
Cities and Towns
Industries
General Site of eutrophication, and consequences seen here.
Agriculture
HOW IS THE EXISITNG FOOD SYSTEM EFFECTING BIODIVERSITY ?
Overview : A macro to micro lens analysis has been carried out across SDG 11, 14 and 15. The concept of eutrophication is prevalent in Haryana, due to the excessive use of fertilisers in the nearby agricultural lands. India ranks second in global phosphorus pollution by human activity. The aim was to represent the systems affected in different ways by eutrophication, and clearly articulate the stakeholders and key challenges for all of them. This helped to focus on a problem area 'eutrophication' which is impacting maximum stakeholders. The design solutions were centered around addressing the source of eutrophication and achieving its elimination .
• Eutrophication is a natural process where the oxygen levels in the lake decreases as it ages and eventually becomes a wetland. But due to pollution and industrialization this process has fastened and the natural process is disrupted.
• Eutrophication has become a global problem that is likely to intensify in coming decades because of increases in human population , demand for food, land conversion , fertilizer usage and run off and nitrogen deposition.
• Wetlands help with storm water detention, flood protection, help with water quality enhancement, food chain support, feeding grounds for juvenile marine fish, carbon storage are being converted to agricultural land. Overfishing changes the species composition in the salt water ecosystem.
• Marshes and mangroves protect coastlines from the damaging effects of wave action and tropical storms. They provide habitats and shelter for many marine organisms. They are the source of nitrogen and other essential nutrients for marine food chains are being negatively impacted with sediments in water from agricultural practices.
• Lakes becomes toxic with high levels of nitrogen and phosphorus . Defined as the inorganic nutrient enrichment of waters, leading to the growth of algae in the lakes impacting bio diversity .