# Causal Loop Diagram Model Building

Standard Operating Procedure

*NOTE: This SOP will detail the process of CLD model building when using the Simple SES DST, we will need to provide guidance on interpreting the information.*

## Purpose:

*A Causal Loop Diagram (CLD) serves multiple purposes; it is a tool that enhances expert dialogue, generating research questions and hypotheses essential for data collection and theory building. As a knowledge management tool, it integrates existing insights, highlighting how elements interact within the broader SES. CLDs also serve as diagnostic tools, identifying policy gaps and operational "leverage points" for targeted interventions (Meadows, 1999). Crucially, the value of a CLD lies largely in its creation process, fostering holistic thinking about SES elements and their interactions, with 90% of its utility embedded in this process and only 10% in the final diagram (Liebovitch et al., 2020).*

## Scope:

*This SOP provides methodological steps to standardise the CLD creation process for SES analysis, ensuring a structured, transparent, and efficient approach to understanding, visualising, and managing complex ecological and social interdependencies. It instructs users to visualise the SES as a whole*.

## Definitions:

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| *Term* | *Definition* |
| *Causal loop diagram* | *Causal Loop Diagrams are rooted in systems thinking and are designed to visually represent the intricate interrelations between system variables (Senge, 1990).* |
| *Connection* | *A connection represents a causal relationship between two elements within the system. It indicates that a change in one element (the cause) will lead to a change in another (the effect), based on available evidence or expert judgement.* |
| *Connection Strength* | *Refers to the intensity of influence that one element has on another within the system, based on available evidence or expert judgement.* |
| *Confidence* | *Confidence represents the level of certainty in the identified connection between two elements, based on available evidence or expert judgement.* |
| *Element* | *An element is a representation of an indicator which is a variable that is liable to vary or change (Oxford English Dictionary).* |
| *Negative Link* | *A negative link represents an inverse relationship between two elements, where an increase in the cause leads to a decrease in the effect.* |
| *Positive link* | *A positive link indicates a direct relationship between two elements, where an increase in the cause leads to an increase in the effect (or a decrease leads to a decrease).* |
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## Procedure:

1. *Using the causal theories built in the previous SOP, use these three adjacency matrices to build a visual representation of the system in focus.*
2. *Begin with adding elements, you can distinguish the various Drivers, Activities, Pressures, Marine Processes and Functions, Ecosystem Services, and Societal Goods and benefits by using different shapes and colours for the elements.*

*Example:*

*A group of different colored shapes

Description automatically generated*

1. *Add connections between the elements in line with the connections and strength assigned in the adjacency matrices, these may be blue for positive connections and red for negative connections. Also, a thick line for strong connections, a thin line for weak connections and a line of thickness between thick and thin for medium connections.*

*Example:*

*A diagram of a diagram

Description automatically generated*

1. *Amend the colour of these lines based on the assigned values in the confidence matrices. This may be a deep blue for strong confidence in a positive connection and gradient to lighter blues for weaker confidence. This premise applied for the negative connections also.*

*Example:*

*A diagram of a diagram

Description automatically generated*

*From these examples, we see that the modelling shows the complexity of interconnections in an SES, hence, in the next SOP, refinement and simplification techniques help reduce this complexity to a manageable size for analysing and designing management measures.*

*A style guide for the elements, connections, and confidence can be found in annex X.*

## Considerations:

*When CLD model building, there is a balance between including relevant elements and adding clarity to the model, alongside increasing the complexity of the model. There is a threshold where the inclusion of everything possibly relevant increases the complexity to too high of a level. Hence, as a user this consideration is paramount throughout the Simple SES modelling process.*