# Contribution of systems thinking and CAS theory to climate-smart agriculture: an example from Ghana

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## Background

Climate-smart agriculture (CSA) has the potential to contribute to the SDGs of achieving zero hunger - reducing land degradation - eliminating poverty - tackling climate change and promoting gender equality. However the scaling-up needed to achieve its goals is challenging as it calls for understanding trade-offs and synergies between often opposing socioeconomic and environmental priorities - over both temporal and spatial scales.

This case study in Ghana examined the use of systems thinking (as a conceptual approach) and Complex Adaptive System (CAS) attributes as tools to inform scaling-up of sustainable food production systems through CSA.

## Methodology

The CSA situation was conceptualized through four systems thinking sessions with women farmers in the climate-smart village (CSV) of Doggoh-Jirapa, northern Ghana. The sessions were guided by the Distinctions, Systems, Relationships and Perspectives (DSRP) framework and Systems Thinking in Practice (STiP) heuristic.

The conceptualized CSA system (Figure 2) was analysed by applying CAS attributes – (1) *Many Interconnected Elements and Open System, (2) Feedback Loops and Time Delays, (3) Dynamic Nature, (4) Self-Organizing and Emergent Order, and (5) Robustness and Resilience.*

**Figure 1**. Systems thinking (Session 2) with women farmers in Doggoh-Jirapa, Ghana.

| Systems Thinking Sessions | DSRP Basic rule | Dominant CAS Attributes |
|---|---|---|
| Session 1 | Distinction (D) Concept-Other | Many Interconnected Elements & Open System |
| Session 2 | Relationship (R) Action – Reaction | Many Interconnected Elements & Open System |
| Session 3 | System (S) Part-Whole | Self-Organizing & Emergent Order |
| Session 4 | System (S) Part-Whole | Feedback Loops & Time Delays; Dynamic Nature; Robustness and Resilience |

**Table 1.** Methodological approach used to operationalize systems thinking and complex adaptive system (CAS)

## Results

The Causal Loop Diagram (CLD) (Figure 2) illustrates the CSA system as perceived by the women farmers. It comprises 17 elements inside the boundaries of the system (in black), two elements outside (in green), and interventions (in red) for scaling-up CSA. Six main feedback loops can be observed.

One feedback loop example: reduction in "Maize Yield" → decrease in "Food Security" → increase in "Wood for Sale & Charcoal Production" → decrease in "Trees on Communal Land" → increased "Erosion" → reduction in "Maize Yield".

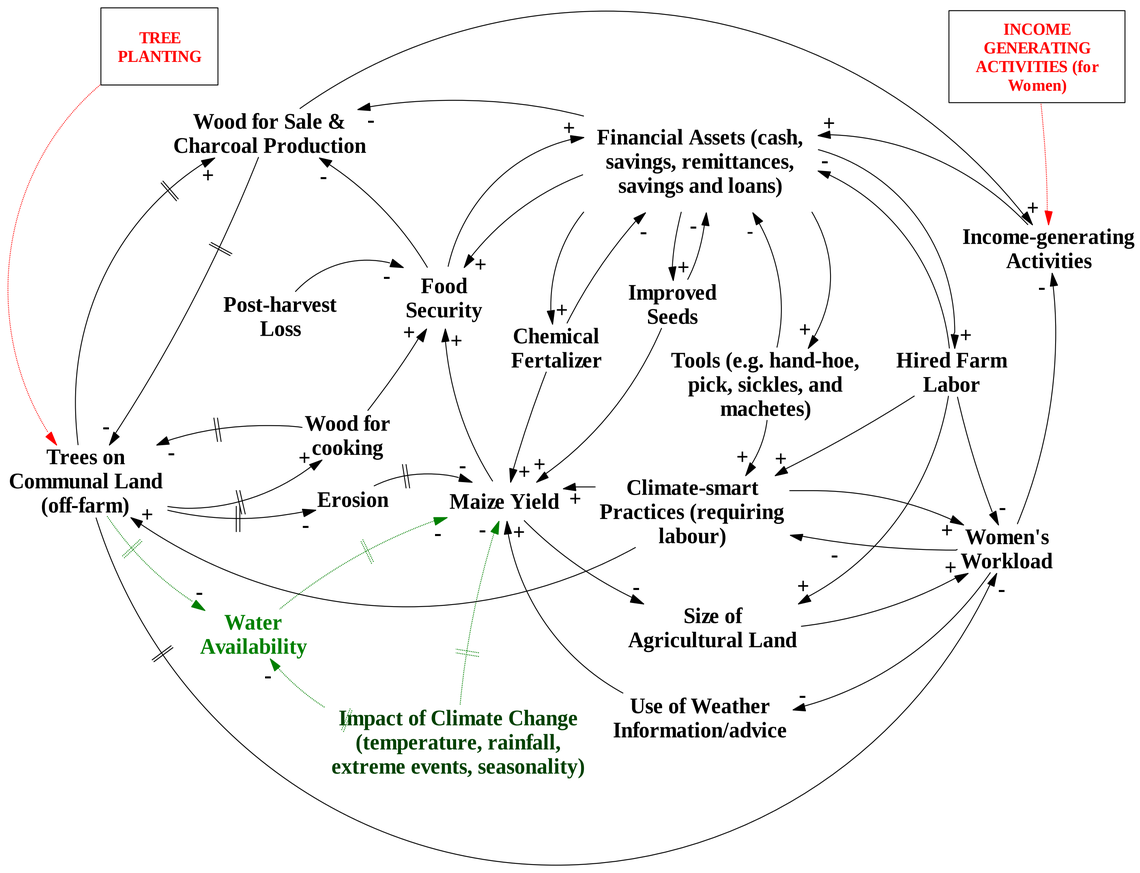


**Figure 2.** CLD representing the Doggoh-Jirapa CSA system from the perspective of women farmers

## Discussion

All five CAS attributes were observed:

1) Many socio-economic and environmental elements, connected on different spatial and temporal scales;
2) Positive and negative feedback loops responsible for emergent system state;
3) Directly and indirectly connected elements simultaneously receive and send signals;
4) Lack of understanding of system-wide impact leads to unpredictable trade-offs;
5) Connectivity between elements enables them to adopt responses to absorb shocks and maintaining robustness of the system.

## Conclusions

- CSA is a highly complex adaptive system comprising multiple socio-economic and environmental elements, interrelations, and feedback loops.
- CAS attributes offer a powerful framework for understanding the complexity and dynamic nature of CSA.
- The DSRP framework is a helpful tool to operationalize systems thinking and conceptualize complexity.
- Feedback systems thinking can assist in understanding the dynamics of the system and identification of interventions to achieve goals.
- Systems thinking and CAS attributes are valuable tools for upscaling CSA as they enable system-wide understanding of benefits and trade-offs over temporal and spatial scales.

*"Everything is connected, whatever we do will have an impact on something, we need to understand what we can do that has a positive impact on our lives"*

Woman Farmer, Doggoh-Jirapa, Ghana

**Figure 3**. Women's income-generating activities

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