Working with the Complexities of an Ecosystem Transition Zone: A Systems Thinking Approach

Extended Abstract

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BACKGROUND

The eastern part of Tirtol Block in Jagatsinghpur district, Odisha, India is generally considered an inland agricultural area. However, field investigations showed that the area faces disaster risks of both inland and coastal systems. The region is influenced by the lower Mahanadi delta, riverine flooding, tidal effects and saline groundwater intrusion. These processes interact with agriculture, ecosystems and local livelihoods. Communities face both rapid-onset and slow-onset risks. Floods, cyclones, heavy rainfall and waterlogging cause immediate damage to crops, infrastructure and livelihoods. At the same time, groundwater salinisation, declining soil fertility, changing biodiversity and declining agricultural productivity develop gradually. These risks interact with each other and affect the long-term resilience of communities. The study uses systems thinking to understand the links between climate risks, agriculture, groundwater, ecosystems and livelihoods. It identifies the feedback structures that influence communities' vulnerability and resilience.

APPROACH

The study used an iterative systems thinking approach to understand the interactions within the region. The Iceberg approach was used to look beyond visible events. Causal Loop Diagrams (CLDs) and System Archetypes were developed to identify key feedback structures, while Behaviour Over Time Graphs were used to understand how change has happened. The research combined desk research with field research. Government reports, District Disaster Management Plans, hydrogeological studies and programme documents were reviewed. Preliminary CLDs were then developed as working hypotheses. These CLDs were tested through Focus Group Discussions and Key Informant Interviews involving more than 100 participants. Participants included farmers, women's Self-Help Groups, Farmer Producer Organisations, PRI representatives, government officials, line departments and civil society organisations. The CLDs were then modified based on the insights from these interactions. They were further refined through participatory systems thinking with CYSD. A multi-stakeholder systems convening was then conducted with community representatives, practitioners, civil society organisations, academics and technical experts.

KEY FINDINGS: THREE SYSTEM TRAPS

The study found that East Tirtol faced disaster risks of both inland and coastal systems. Riverine flooding, tidal influences, groundwater salinity and overlapping hazard regimes further shape the system. Moreover, freshwater and saline systems interact with agriculture, ecosystems and livelihoods. Floods and cyclones cause immediate disruption, while groundwater salinisation, soil degradation, declining agricultural productivity and ecological changes develop gradually. These processes interact and contribute to long-term vulnerability. Using causal loop diagrams and system

archetypes, the study identifies three key system structures that shape vulnerability and resilience in East Tirtol:

- **Fixes that Fail (Agricultural Intensification and Declining Soil Fertility):** The use of fertilisers and pesticides helps farmers maintain paddy yields in the short term. Over time, however, continued use contributes to declining soil fertility and increasing pest resistance. This creates a cycle in which farmers need to continue using or increase the use of agricultural inputs. MSP, post-disaster compensation and limited markets for other crops further reinforce the dominance of paddy cultivation.
- **Tragedy of the Commons (Groundwater Extraction and Salinity Intrusion):** Paddy cultivation creates a strong need for irrigation. Farmers therefore increasingly depend on groundwater and deeper borewells. While this supports agricultural production in the short term, increasing extraction reduces groundwater availability and contributes to salinity intrusion. Coupled with saline water ingress, declining water quality then affects agriculture, drinking water, health and household expenditure.
- **Fixes that Fail (Agricultural Intensification and Human–Snake Interactions):** In some cases, the use of pesticides and fertilisers in agriculture creates a positive side effect by reducing snakes and their prey in agricultural fields. This reduces human–snake interactions in the fields. However, over time snakes change their routes in search of food and habitat and move towards other territories (homes, roads, etc.). Floods and warmer temperatures further disturb their habitats. Thus, fixing a problem in one place (reduced human and snake interactions in the field) creates unintended consequences elsewhere (increase in interactions outside agricultural fields).

Across these findings, the study shows that climate, agriculture, groundwater, ecosystems, livelihoods and institutional responses are closely connected. Changes in one part of the system can create effects elsewhere. This highlights the need to address these challenges together rather than through isolated interventions.

CONCLUSION & WAY FORWARD

The study shows that East Tirtol exhibits characteristics of an ecosystem transition zone where freshwater and saline systems, coastal and inland risks interact. These interactions create both rapid- and slow-onset risks. The findings show that many responses that provide short-term benefits can also create unintended consequences over time. Systems thinking helps make these feedbacks visible. This can support more integrated and place-based approaches to disaster resilience, sustainable agriculture, groundwater management and livelihoods.

Through the systems convening, the study identified different pathways for strengthening resilience. These include sustainable groundwater management, livelihood and cropping system diversification, ecosystem restoration and biodiversity conservation, all housed under a Regenerative Agriculture program. The study highlights the need to move beyond relief-oriented disaster management towards resilience-building approaches that address both rapid-onset and slow-onset risks. Potential next steps include community-based systems thinking exercises to validate the above interventions. And integrate them with Village Disaster Management Plans and Gram Panchayat Development Plans. A multi-actor working group can potentially guide programme design while ensuring coordination, local ownership and long-term accountability.