REGIME SHIFTS IN SOCIAL-ECOLOGICAL SYSTEMS

UNIVERSITEIT iYUNIVESITHI STELLENBOSCH UNIVERSITY 100 1918·2018

forward together · saam vorentoe · masiye phambili

CST Centre for Complex Systems in Transition

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Regime shifts are sudden, long-lasting changes in the structure and function of social-ecological systems that may have profound effects on human economies and societies. Regime shifts have been documented in a variety of systems, including coral reefs, freshwater lakes, marine systems and savanna rangelands, as well as in human behavior, economies and political systems. Accounting for potential regime shifts is key to achieving sustainable development, reducing poverty and halting biodiversity loss, due to their substantial impacts on ecosystem services and human wellbeing.

WHY DO REGIME SHIFTS MATTER?

Regime shifts often occur unexpectedly, are difficult to anticipate, and may be costly, or even impossible to reverse. Regime shifts in social-ecological systems may impact the supply of ecosystem services, such as crop production and flood regulation, on which human societies depend, and which may have major impacts on human economies, security and health.

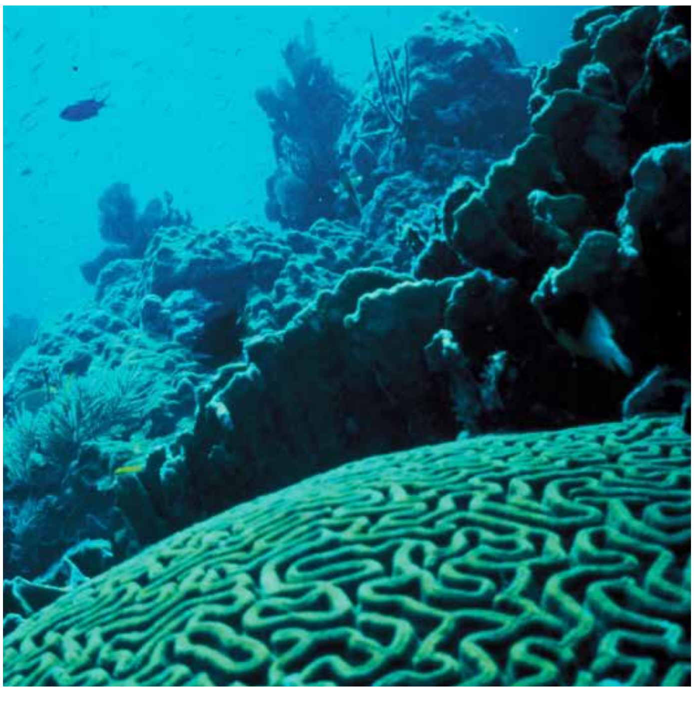
Understanding regime shifts is important for the development of management policies and practices that assure the provision of ecosystem services, including provisioning services or 'goods' such as timber or fish; regulating services, such as climate regulation and including carbon sequestration; and cultural services such as recreational and aesthetic benefits.

HOW DO REGIME SHIFTS OCCUR?

Regime shifts are associated with the transgression of tipping points. A tipping point is a critical threshold at which there is a shift in the dominant feedbacks and dynamics of the system, which means that the system reorganizes and becomes structured and functions in a different way. When the system is close to a tipping point, a small perturbation can shift the system across the threshold and fundamentally alter the dynamics and future development trajectory of a system. Examples of perturbations include climatic fluctuations, large storms, fires, invasive species, or a disease that wipes out a substantial fraction of some important functions or species, thus precipitating a sudden shift in the dominant feedback processes within the system.

Slow, gradual changes in the system, such as a lake slowly filling up with sediment, push a social-ecological system towards a threshold. Such changes and loss in resilience often go unnoticed until a regime shift happens. Once the system is close to the threshold, a regime shift can be triggered by even a small shock to the system, such as a thunderstorm or fire that usually would not have any dramatic impacts. For example, freshwater lakes can shift from a clear water regime that supports fisheries to an algae-dominated regime where the low oxygen levels mean that fish cannot survive. As the lake becomes more polluted through fertilizer run-off, it becomes increasingly likely that a major algal bloom can be triggered by a large thunderstorm that leads to a sudden flush of nutrients into the lake.

Example of a coral-dominated reef and algae-dominated reef



CASE STUDY: SOCIAL-ECOLOGICAL REGIME SHIFT IN THE MARADI AGRO-ECOSYSTEM

Historically, sparse, rural populations cultivating small fields amidst surrounding bush were characteristic of Niger's landscapes, particularly in the Maradi Region. Population densities were small with sufficient yields and ample supplies of timber and other forest products from natural woodlands. Fallow practices were common, allowing fields to rest and trees and shrubs to be regenerated to provide extra wood before being cleared for planting. The fallow time played an important role in maintaining the natural productive cycle of the environment and provided a host of services such as soil and water conservation.

Then, in the 1930's, land clearing and tree felling became common practices as the colonial administration pushed Nigerien farmers to grow export crops like cotton and implemented policies that provided disincentives for farmers to care for their land. Such disincentives included a new land law that established the national government as the owner of all trees and where Nigeriens were required to purchase permits to use them. Native trees and shrubs were cleared, exposing the soils to the fierce Sahara winds which resulted in soil erosion and a transition towards a desert ecosystem.

The shift from a productive land use to a desert regime impacts the biodiversity of the area, results in decreased soil fertility and productivity and therefore has impacts upon provisioning services such as fuel-wood and food for the local communities. The human impact was significant: increased poverty and destitution translated into hunger, malnutrition, imbalanced diets and even death.

HOW CAN UNDERSTANDING OF REGIME SHIFTS BE APPLIED?

The resilience of social-ecological systems relies on identifying and detecting early warning signs and developing tools for tracking changes in the resilience of different regimes. The Regime Shifts Database **(www.regimeshifts.org)** provides a synthesis of different types of regime shifts documented in social-ecological systems. This online open-access database describes the different regimes that can exist in social-ecological systems, the ecosystem services provided by each regime, and which societal groups benefit from these services. The database describes the main drivers that precipitate the regime shift, as well as the shocks and slow internal system changes that can lead to the regime shift. This platform allows for the identification of policy-relevant regime shifts for purposes of research, as well as facilitating the planning, assessment and management of various social-ecological systems in the face of uncertainty.

> "Managing complex systems in the face of uncertainty requires avoiding undesirable shifts, reversing unwanted shifts, or encouraging shifts to more desirable regimes."

Identifying and managing slow, underlying drivers that sustain a system's capacity to absorb shocks and disturbances, while managing key drivers and shocks that may 'push' or 'pull' the system into an alternate regime is critical. A practical way forward in the face of uncertainty includes setting safe boundary levels to manage critical thresholds and adopting an adaptive management approach by treating management actions as experiments while constantly monitoring the outcomes and reassessing potential threshold levels.

EXAMPLES OF REGIMES

KEY DRIVERS	REGIME 1	REGIME 2	IMPACTS ON ECOSYSTEM SERVICES
- Over-fishing - Pollution - Climate change	**Coral-dominated reef** 	**Algae-dominated reef** 	- Biodiversity - Fisheries - Recreation - Tourism - Jobs - Coastal protection
- Deforestation - Change in fire frequency - Droughts	**Forest** 	**Savanna** 	- Biodiversity - Climate regulation - Water cycling - Food production - Soil regulation - Soil erosion
- Deforestation - Coastal erosion - Climate change	**Mangrove forest collapse** 		- Biodiversity - Fisheries - Timber regulation - Soil erosion - Soil regulation
- Greenhouse gas concentrations	**Arctic summer ice loss** 		- Fisheries - Food and nutrition - Livelihood and economic activity - Security of housing and infrastructure
- Climate change - Coastal erosion - Nutrient input	**Salt marsh** 	**Tidal flat** 	- Pollution - Filtration - Storm protection - Biodiversity - Food production

FURTHER READING

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FOR FURTHER INFORMATION PLEASE CONTACT: CENTRE FOR COMPLEX SYSTEMS IN TRANSITION

Stellenbosch University, Private Bag X1, The Stables at 19 Jonkershoek Road, Stellenbosch, South Africa**Tel:** +27 21 808 9607 | **Website:** www.sun.ac.za/cst