Case: The Tsembaga of New Guinea

Summary
Tsembaga Maring are a group of horticulturists who live in the highlands of New Guinea. The main resource upon which they rely is swidden agriculture. The Tsembaga also practice animal husbandry - the main domesticated animal being pigs. The Tsembaga derive little energetic value from pigs. Pork probably serves as a concentrated source of protein for particular segments of the population as it is rarely eaten other than on ceremonial occasion. Pigs do, however, play an important role in the ritual activity of the Tsembaga. Part of the ritual activity of the Tsembaga may act as institutions that govern resource use. This case investigates the role of intitutions related to the ritual activity to prevening over exploitation of the renewable resource (soil and soil fertility) upon which the Tsembaga rely.

Institutional Analysis
For the robustness of their livelihood, ethnographic studies suggest that the Tsembaga people adopted three social institutions: (1) material and personnel exchanges with other tribes through marriages and ritual activities; (2) occupying semi-fixed territories that intersperse in times of resource abundance and become more rigidly separated in times of resource scarcity; and (3) the ritual of "Kaiko" through which they self-regulate their population level and thus prevent the degradation of their ecosystem. The first two items relate to more even distributions of resource allocations among people and harvesting pressure on ecological systems, which serve to increase the shocks the Tsembaga can absorb in times of resource shortage and degradation. In this analysis, we focus on the last item – the ritual of Kaiko and its self-regulating mechanism.

Kaiko is a year-long pig festival and serves to end a 5–25 year-long ritual cycle that is coupled with pig husbandry and warfare. In a single cycle, human and pig populations grow until the work required to keep pigs is too great. As pigs multiply in numbers, pigs inevitably invade and degrade the gardens of neighboring groups and the pig owners of such incidents may get killed. The Tsembaga do not retaliate and this results in 'unresolved' conflicts between the Tsembaga and other groups. Finally, when the Tsembaga perceive that there are just too many pigs for them to handle, a Kaiko is called and most of the pigs are slaughtered. Then, the Tsembaga are released from the taboo prohibiting conflicts with other groups. Tribal warfare ensues and killings happen until both sides agree that 'enough' casualties have resulted. This ends a Kaiko with the net outcome of the pig and human populations reduced to levels that do not cause ecological degradations. A new cycle of human an pig population growth begins again and the same process is repeated. This is the self-regulating mechanism of Kaiko for controlling the population level of Tsembaga. This likely prevented the destruction of their resource base from overexploitation.

For governing the commons, three aspects are important: how necessary institutions (public good) are provided, how participants commit themselves to the rules of the game, and how the rules are enforced and monitored. We can immediately see that

Kaiko is the institution (public good) providing the rules of the game. It is supplied by their tradition which is deeply engrained into their culture. Within Kaiko, pig husbandry is a monitoring device (public good) of the ecological state. Raising pigs also takes away significant portions of human effort that would otherwise be directed toward greater ecological degradation (i.e., more time spent on harvesting and mating and nurturing children). Participants' commitment toward Kaiko and its enforcement and monitoring are maintained through their culture and tradition – Kaiko is tightly woven into their lives.

A simple mathematical model of Kaiko's self-regulating mechanism is provided in the models library. This is done to illustrate how the self-regulating mechanism can stabilize the system and to reveal any hidden insights that may affect the outcome. For the Tsembaga case, it turns out that a number of site-specific properties indeed could play crucial roles. First, the system stabilizes if and only if the relationship between the death rate from tribal conflicts and the human population level is nonlinear. No matter how effect the institutions are, the system will not stabilize if this condition is not met. This nonlinearity condition was probably satisfied in the case of Tsembaga because the human and pig populations grow together. Because the destruction caused by pigs likely grows nonlinearly with their population, the death rate could grow nonlinearly as humans and pigs grow in numbers. Second, the model shows that when humans adjust harvesting effort levels to better adapt to situations and strive to maintain the status quo population levels, there could be social delays in perceiving alarm signals that their resource systems are being degraded beyond capacity. This could destabilize the system and induce dramatic collapse of human population. Such adjusting behavior could also take away the necessary time scale for institutional adaptation to occur (i.e., the collapse of social systems is too sudden for anyone to adapt).

Robustness of the System

The resource user is the Tsembaga Tribe. The resource is the Tsembga swidden agriculture and the staple foods it generates. The public infrastructures are the following social institutions: (1) Kaiko as a social ritual that sanction tribal warfare, harvesting and resetting of the pig husbandry ; (2) raising of pigs as monitoring device (part of Kaiko); (3) resource sharing tradition with allies; and (4) interspersing behavior in times of hardship. The public infrastructure providers are the users themselves. The provision of the infrastructure and the participation by the users are guaranteed because such activities are tightly inter-woven into their lives – their culture and tradition. The public infrastructure influence the resource dynamics through the following mechanisms: (1) the invading of pigs signals an alarm that the resource system is being pressured beyond capacity; (2) pressure on the resource system is alleviated through interspersing behavior; (3) harvests are more evenly distributed among people through exchange networks; and (4) reduced population level from warfare puts less pressure on the resource system. Since climate variability is probably low in highlands of New Guinea (e.g., no droughts and flooding), the likely disturbance to the resource system and infrastructure is the endogenous pressure of overexploitation and human population growth. The likely disturbance to the users and

providers are the warfare with neighboring tribes and delayed perception that their resource systems are being degraded beyond capacity. The overall system is robust because the infrastructure provided (i.e., the resource sharing strategy, the harvesting effort interspersing strategy, and the Kaiko ritual) counter the outlined disturbances. Figure 1 and Table 1 summarize the outlined components and their interactions.

Figure 1: Generic Robustness Diagram

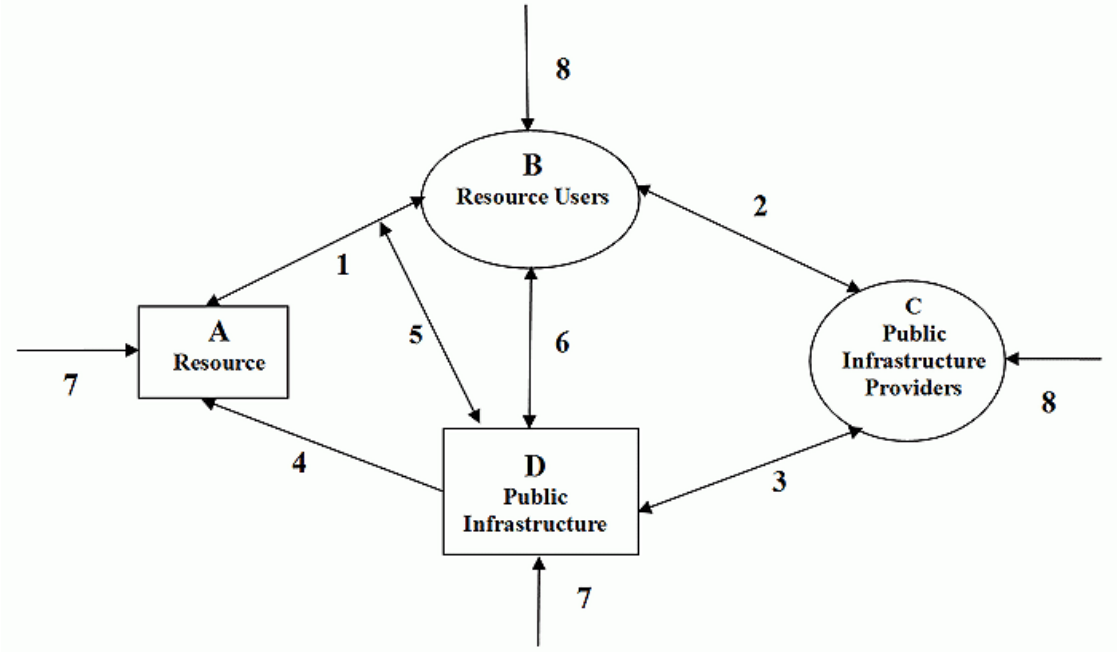

Table 1: The Robustness of Tsembaga

Resource Users	Tsembaga Tribe
Public Infrastructure Providers	Tsembaga Tribe
Public Infrastructure	• Kaiko as a social ritual that sanction tribal warfare, harvesting and resetting of the pig husbandry • Raising of pigs as monitoring device (part of Kaiko) • Resource sharing ritual/tradition with allies • Interspersing behavior in times of hardship
Resource	Slash-and-burn agriculture
Resource Users and Resource (1)	Harvesting
Resource users and public infrastructure providers (2)	Users and providers were probably the same.
Public Infrastructure Providers and Public Infrastructure (3)	The provision was natural. It was part of Tsembaga tradition and culture.
Public infrastructure and resource (4)	Pigs invade and destroy slash-and-burn farm fields.
Between public infrastructure and resource dynamics (5)	• The invading of pigs signals an alarm that the resource system is being pressured beyond capacity. • Pressure on the resource system is alleviated through interspersing behavior. • Harvests are more evenly distributed among people through exchange networks. • Reduced population level from warfare puts less pressure on the resource system.
Between resource users and public	Villagers participate because it is their culture and tradition

infrastructure (6)	to do so.
External forces on public infrastructure and resource (7)	Overexploitation (endogenous disturbance)
External forces on social actors (8)	• Delayed perception that their resource systems are being degraded beyond capacity. • Warfare with hostile neighbors.

Citations

Rappaport, R. A. 1968. Pigs for the Ancestors. New Haven: Yale University Press.
Anderies, J. 1998. Culture and human agro-ecosystem dynamics: the Tsembaga of New Guinea. Journal of Theoretical Biology. 192:515 –530.