Case: The Hohokam Cultural Sequence, Irrigators and Hunter-gatherers

Introduction

The Hohokam is a Native American cilivilization that emerged and occupied the present day Phoenix Basin area and its outer bounds for a thousand years. The archeological records indicate that the Hohokam society evolved into a complex irrigation society and reached its peak in levels of population, social institutions, and irrigation infrastructure by the 11th century.

Perplexingly though, the Hohokam society subsequently declined and collapsed by the mid 14th century. As they declined, the Hohokam abandoned their irrigation-related infrastructure and social institutions. The motivation behind their evolution into a complex irrigation society is not hard to deduce – irrigation and associated institutional changes tend to make their subsistence robust to some familiar disturbances. This is so because such 'buffering' infrastructure can reduce the impact of climate variability (e.g., frequent local droughts) on the food production level. The reason why they collapsed, however, is not clearly known.

Based on the archeological records, this case explores the likely social and ecological interactions that took place and how those interactions impacted the robustness of the Hohokam society. This can shed some light on why the Hohokam collapsed.

The Hohokam Cultural Sequence

In this section, based on the archeological records, we highlight the likely progression of institutional change and infrastructure investments undergone by the Hohokam. In so doing, we also highlight how the robustness of their social-ecological system might had co-evolved. This co-evolution between social and physical infrastructure and the robustness of their social-ecological system may shed light on why the Hohokam collapsed.

1500 BC–AD 1

In this period, the Hohokam was a predominantly hunter-gatherer society with limited agricultural capacity. There was no sophisticated irrigation infrastructure or social institutions.

Pioneer (1–750)

More irrigation practices occurred during this period. Multiple villages began to cooperate and manage shared irrigation canals along the Salt River. The social entity of 'courtyard groups' also started to form, possibly functioning as an informal organization to coordinate multiple village cooperation.

The likely picture on the robustness of the system is portrayed by Figure 1 and Table 1. The resource users were hunter-gatherers and small-scale irrigators. The resource systems they depended on were local wild resource stocks and riparian lands suitable for small-scale irrigation. The local wild resource stocks likely produced protein-rich food sources while the riparian lands produced carbohydrate-rich foods. There were no

dedicated public infrastructure and their providers. The system faced two primary disturbances: local droughts impinging on the local wild resources and small flood events impinging on the riparian lands. Note, however, that these two disturbances are mutually exclusive, meaning that droughts don't happen when flooding is around and vice versa. As such, the overall system was fairly robust for ensuring their subsistence needs. This is so because the Hohokam could dynamically switch between these two resource systems or co-use them depending on the situation.

Although the Hohokam heavily depended on the wild resources for food during this time, it is likely that crude social institutions emerged for co-managing the multiple village canals. This is so because collective action problems are bound to arise in a common-pool resource (CPR) situation like irrigation systems in the absence of shared norms and rules. The archeological evidence of courtyard groups suggests that these groups might had functioned as the organization that governed such collective action problems. Because the courtyard groups may had been very crude and the irrigation systems were small in scale, the robustness diagram in Figure 1 does not include them.

Figure 1: The Pioneer Period (1–750)

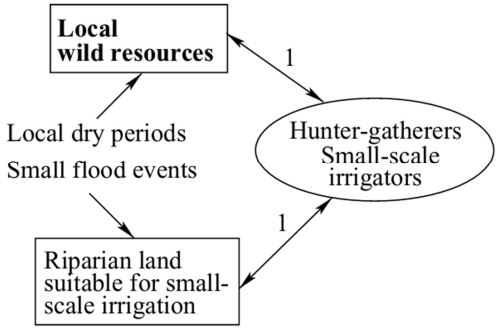

Table 1: The Pioneer Period (1–750)

Resource Users	• Hunter-gatherers (U) • Small-scale irrigators (U)
Public Infrastructure Providers	N/A
Public Infrastructure	N/A
Resource	• Local wild resource (RS) producing protein-rich food (RU) • Riparian lands (RS) producing carbohydrate-rich food (RU)
Resource Users and Resource (Link 1)	• Hunter-gatherers harvesting from the local wild resources • Small-scale irrigators harvesting from the riparian lands
Resource users and public infrastructure providers (Link 2)	N/A
Public Infrastructure Providers and Public Infrastructure (Link 3)	N/A
Public infrastructure and resource (Link 4)	N/A
Between public infrastructure and	N/A

resource dynamics (Link 5)	
Between resource users and public infrastructure (Link 6)	N/A
External forces on public infrastructure and resource (Link 7)	• Local droughts • Small flood events
External forces on social actors (Link 8)	N/A

Colonial (750–900)

In this period, the social infrastructure of 'ball courts' began to appear and expand in the Hohokam area. It is suggested that these ball courts facilitated social rituals that involve cross-community communications and commodities exchanges among diverse groups of people. Thus, the presence of the ball courts implies the emergence of regional-scale trade networks that amplified the spatial scale of accessible wild resources for the people. Through the ball courts and the trade networks, the Hohokam likely reduced the transaction cost associated with the commodity exchanges. This could have made the Hohokam more robust to local-scale disturbances (i.e., local droughts and small-scale flooding events).

Sedentary (900–1150)

This period represents the continuation of the trend that began in the Colonial Period. The ball courts proliferated. Mass production of pottery emerged – a sign that implies the establishment of task specialization and regional-scale trades. It is likely that the extent of the regional trade networks reached its peak during this period. It is also likely that the irrigation-related infrastructure became increasingly sophisticated in both physical and institutional dimensions. Although the irrigable lands were still not the single dominant resource system utilized, it must had become a major component. As such, it is likely that the Hohokam depended heavily on a mix of resource systems comprised of riparian lands, irrigable lands, and regional wild resources.

The robustness of the Hohokam throughout the Colonial Period and Sedentary Period is portrayed in Figure 2 and Table 2. Four resource systems were actively utilized by the resource users: local wild resources, regional wild resources, riparian lands, and irrigable lands. The resource users included hunter-gatherers, small-scale irrigators, and potters. The ball courts and regional trade networks proliferated, becoming the key public infrastructure of the society. Moreover, an elite class controlling the ball courts likely emerged and served as the public infrastructure providers. The ball courts and trade networks in turn influenced the resource user-resource system interactions by reducing associated transaction costs. The resource users contributed to establishing and maintaining the ball courts. There were also active power relationships between the resource users and the public infrastructure providers (e.g., users making policy recommendations and monitoring the providers, providers coordinating the users, etc.). Because of the increased levels of social and physical infrastructure (e.g., regional trade networks and more sophisticated irrigation systems), the overall system added more potential sources of vulnerability: local droughts to local wild resources, regional droughts to regional wild resources, small flood events to riparian lands, large flood

events to irrigable lands, and power struggles among commoners and elites. Note that the regional wild resources and irrigable lands could buffer the impact of local droughts and small flood events respectively. This means that vulnerability from climate variability was reduced by the changes introduced. This likely made the overall system fairly robust against multiple disturbances while supporting more population through increased food productions. However, the same changes also made the system vulnerable to new potential disturbances: regional droughts and large flood events. In other words, old vulnerabilities traded off with new ones as institutional changes and capital investments were made.

Figure 2: Late Pioneer through middle Sedentary Period (700--1070 A.D.)

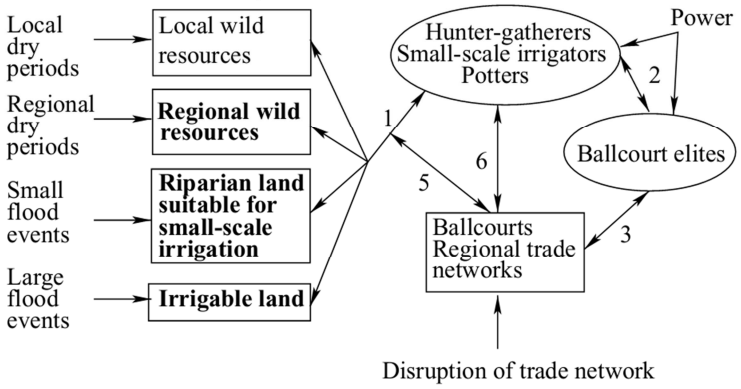

Table 2: Late Pioneer through middle Sedentary Period (700--1070 A.D.)

Resource Users	• Hunter-gatherers (U) • Small-scale irrigators (U) • Potters (U)
Public Infrastructure Providers	• Ball court elites (GS1, GS6)
Public Infrastructure	• Ball court (RS4) • Regional trade networks (GS3)
Resource	• Local wild resource (RS) producing protein-rich food (RU) • Regional wild resource (RS) producing protein-rich food (RU) • Riparian lands (RS) producing carbohydrate-rich food (RU) • Irrigable lands (RS) producing carbohydrate-rich food (RU)
Resource Users and Resource (Link 1)	• Small-scale irrigators harvesting from the riparian lands and irrigable lands • Other users obtaining local and regional wild resources through the trade networks
Resource users and public infrastructure providers (Link 2)	• Ball courts and their elites probably engaged the resource users through open communication • Elites could be the direct users of the infrastructure themselves • Flexible co-management (e.g., collectively making rule changes) (GS6)
Public Infrastructure Providers and Public Infrastructure (Link 3)	• The elites probably coordinated the ball courts and trade networks (O1)

Public infrastructure and resource (Link 4)	N/A
Between public infrastructure and resource dynamics (Link 5)	• Ball courts facilitate regional trade activities by reducing transaction costs
Between resource users and public infrastructure (Link 6)	• Co-production (GS6)
External forces on public infrastructure and resource (Link 7)	• Local droughts • Small flood events • Regional droughts • Large flood events • Disruption of trade network
External forces on social actors (Link 8)	• Power struggles

Classic (1150–1450)

The Hohokam society gradually declined and eventually collapsed around 1450. The archeological records suggest that significant institutional changes and transformations of physical capital occurred during this period. The institutional changes undergone by Hohokam can be inferred from a number of archeological findings: above ground residential areas with compound walls, rectangular platform mounds with compound walls, the abandoning of open ball courts, and more nucleated community centers. The presence of above ground residential areas with compound walls likely suggests that institutional changes tied with more strict property rights regime got established. The rectangular platform mounds with compound walls is linked with the emergence of more strict social stratification distinguishing elites and commoners. The abandoning of the ball courts and more nucleated community centers suggest that the cross-community interactions and regional trading activities declined – a sign that institutions favoring more closed forms of social interaction got foot-hold in the society. For the physical capital, it appears that the irrigation-related infrastructure became much more extensive. The Hohokam heavily utilized their irrigable lands and depended on them primarily.

The robustness of the Hohokam system throughout the Classic Period is portrayed in Figure 3 and Table 3. The resource users now included only large-scale irrigators and potters. Although the active resource systems still included other sources, the primary resource system was the irrigable lands alone. The main public infrastructure were large-scale irrigation systems and the platform mounds. The public infrastructure providers may had been those elites controlling the platform mounds. The vulnerabilities of the system were as the following: local droughts to local wild resources, regional droughts to regional wild resources, small floods to riparian lands, large floods to irrigable lands, and disruption of infrastructure maintenance (i.e., collective action problems), large flood events to the public infrastructure, and power struggles among commoners and elites. Note that the overall system now became very sensitive to the collective action dilemma of maintaining the extensive irrigation infrastructure. Although the increased level of irrigation made the overall system less vulnerable to other disturbances, it probably made the system more vulnerable to the provision dilemmas of CPR situations. This is a tradeoff in vulnerability.

Figure 3: Late Sedentary through Classic Period (1070--1450 A.D.)

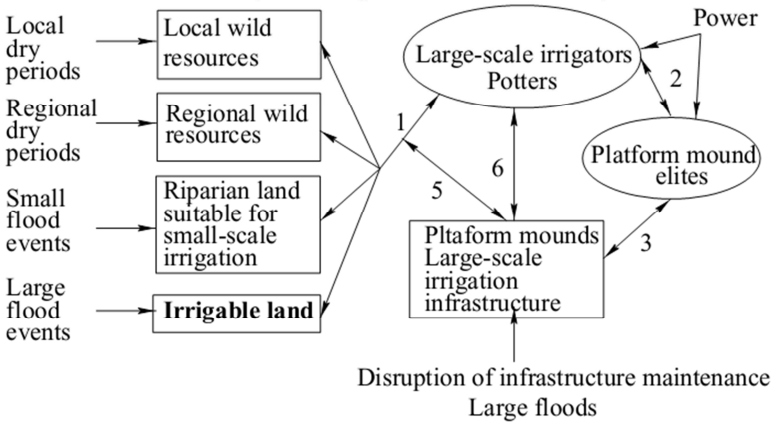

Table 3: Late Sedentary through Classic Period (1070--1450 A.D.)

Resource Users	• Large-scale irrigators (U) • Potters (U)
Public Infrastructure Providers	• Platform mound elites (GS1, GS6)
Public Infrastructure	• Above ground platform mounds (RS4) • Large-scale irrigation systems (RS4)
Resource	• Local wild resource (RS) producing protein-rich food (RU) • Regional wild resource (RS) producing protein-rich food (RU) • Riparian lands (RS) producing carbohydrate-rich food (RU) • Irrigable lands (RS) producing carbohydrate-rich food (RU)
Resource Users and Resource (Link 1)	• Most resource users heavily depend on irrigable lands for subsistence • Local and regional wild resources and riparian lands are not as important
Resource users and public infrastructure providers (Link 2)	• Platform mounds and their elites probably engaged commoners authoritatively through top-down unilateral management (GS6) • Elites were probably not the direct users • Less chance for co-management
Public Infrastructure Providers and Public Infrastructure (Link 3)	• The elites governing the platform mounds and large irrigation systems
Public infrastructure and resource (Link 4)	N/A
Between public infrastructure and resource dynamics (Link 5)	• Irrigation systems are critical for proving food
Between resource users and public infrastructure (Link 6)	• Co-production (GS6) but sensitive to collection action problems
External forces on public infrastructure and resource (Link 7)	• Local droughts • Small flood events • Regional droughts • Large flood events • Disruption of trade network (i.e., collective action

	problems)
External forces on social actors (Link 8)	• Power struggle s

Key Insights

Although we can only speculate, the sequence of events described highlights the tradeoffs in vulnerability that arise when societies attempt to build robustness to frequent kinds of disturbances. That is, as societies build robustness by instituting buffering infrastructure (e.g., irrigation-related physical infrastructure and social institutions) in order to reduce certain variability or vulnerabilities (e.g., fluctuations in food supply from climate variability), they also necessarily introduce new vulnerabilities (e.g., large flood events that can destroy their irrigation infrastructure as well as collective action problems associated with providing irrigation systems). This is the principle of 'conservation of vulnerabilities' – systems cannot eliminate vulnerabilities completely but only trade off robustness among different domains of vulnerabilities.

Another interesting insight from the Hohokam cultural sequence could be the 'hidden social-ecological dynamics' or 'physical geometry' of the problem that drove their collapse. This is best illustrated by the inter-play between the 'buffering infrastructure" type robustness strategy and another robustness strategy in which societies switch back and forth among a portfolio of resources that do not co-vary under a common disturbance. In the case of Hohokam, the latter strategy would be switching to irrigation in times when wild resources become degraded by local droughts or over-exploitation. When the wild resources get regenerated, they would then switch back to consuming the wild resources. Conversely, if the irrigation infrastructure gets destroyed by large floods, they would switch to depending on the wild resources more until their irrigation system becomes functional again. This 'switching among portfolio' type robustness strategy appears just as effective. However, the critical insight here is that this strategy does not always work – under certain configurations of physical parameters, the system might become so fragile to the point that underlying dynamics would cause the system to collapse no matter is done. For the Hohokam, the critical physical parameter could be the ratio between the levels of physical capital (i.e., irrigation system) and population, which is influenced by the level of investments in the physical infrastructure among others. When this ratio is high, their social-ecological system becomes so fragile to the point that even a minor disturbance can set their system on the trajectory of collapse. Once the system is on this trajectory, it cannot escape because the underlying dynamics will pull them to the stable equilibrium of collapse. The Hohokam may attempt the usual 'switching' strategy to escape and it may appear to work initially but the hidden dynamics will drive the system to collapse eventually.

Citations

Anderies, J. M. (2006). Robustness, institutions, and large-scale change in social-ecological systems: the Hohokam of the Phoenix Basin. Journal of institutional economics, 2(2), 133–155.