SUSAKI: Socioecological transitions, sustainability and collapse of island communities: the case of Samothraki

A. Project Description

1. Aim of the project

The current project aims at analysing society-environment relations on a small Greek island. Our proposed research is in line with the LTSER tradition (Long Term Socio-Ecological Research, see Singh et al. 2013) and builds upon a sociometabolic understanding of socioecological systems (Haberl et al. 2011). We seek to explore the factors that cause societies to prosper and sustain themselves on islands and those that lead to collapse. On the island we investigate, a number of historical cases of collapse have occurred, in the sense of breakdown of complexity and rapid population decline (see Tainter 1988). At present there is a fragile situation of slow decline of population and ecological challenges that might possibly be brought to a tipping point by impacts of the Greek economic and governance crisis and climate change. The island community has decided to make an effort at turning the whole island into a Biosphere Reserve by UNESCO standards.[1] This project aims at giving scientific support to this process, by generating improved insights from the past about collapse as a phase in the history of societies, as is "successful evolution" and "sustainable development" (Young et al. 2007), and identifying the threats and possible ailments in order to avoid them for the present**.**

In order to investigate the changes on the island's socioecological system over a longer period, we will extend our focus on the recent past (1945 – present), when the island is experiencing a transition process from an agrarian to a modern society and a gradually rising imbalance from ecological overexploitation. With this project we do not only want to study the changing impacts society has on the environment, but also other factors causing population and complexity decline, e.g. the importance of the connection to the mainland or emigration. The overarching aims of the project are the following:

- Identify the key conditions of self-reproduction of the socioecological system of the island of Samothraki, as well as the main drivers of transformation.
- Reconstruct the current system's compartments and dynamics, in order to make recommendations on how to avoid critical tipping points at present and strive for a sustainable future.

[1] Following a feasibility study and comprehensive consultation with stakeholders from 2008-2011 (see Fischer-Kowalski et al. 2011) finally an application to UNESCO was unanimously supported by the municipal council and signed by the island's Mayor. The application was submitted by the Greek National MAB committee to UNESCO and is currently under review. UNESCO's Seville Strategy aims at raising Biosphere Reserves to be the principal internationally-designated areas dedicated to sustainable development in the 21st century (UNESCO 1996).

2. Research approach

Guiding paradigm for understanding the self-reproduction of socioecological systems is a model of interaction between cultural and natural spheres of causation (Fischer-Kowalski and Weisz 1999). In the realm where these two spheres interact, namely the hybrid (that is, both naturally and culturally governed) compartments of the system, we deal with a stocks and flows model. The system and its various compartments reproduce themselves as long as the flows required for maintaining the stocks can be organized. Figure 1 gives a comprehensive overview of this model. The centre is occupied by the core (hybrid) compartments of the socioecological system on the island: the local population, the visitor population, and the three key economic sectors including the biophysical infrastructures (in the case of agriculture: the livestock) these sectors require and maintain. The local population invests labour into the economic sectors, and receives income and services in return. The visitor population brings money from outside, and receives services in return. All economic sectors draw on certain resources from the marine and/or terrestrial environment, and generate wastes in return. The behaviour of all actors is guided by the island's legal and cultural system, and this system in turn may incorporate new experiences.

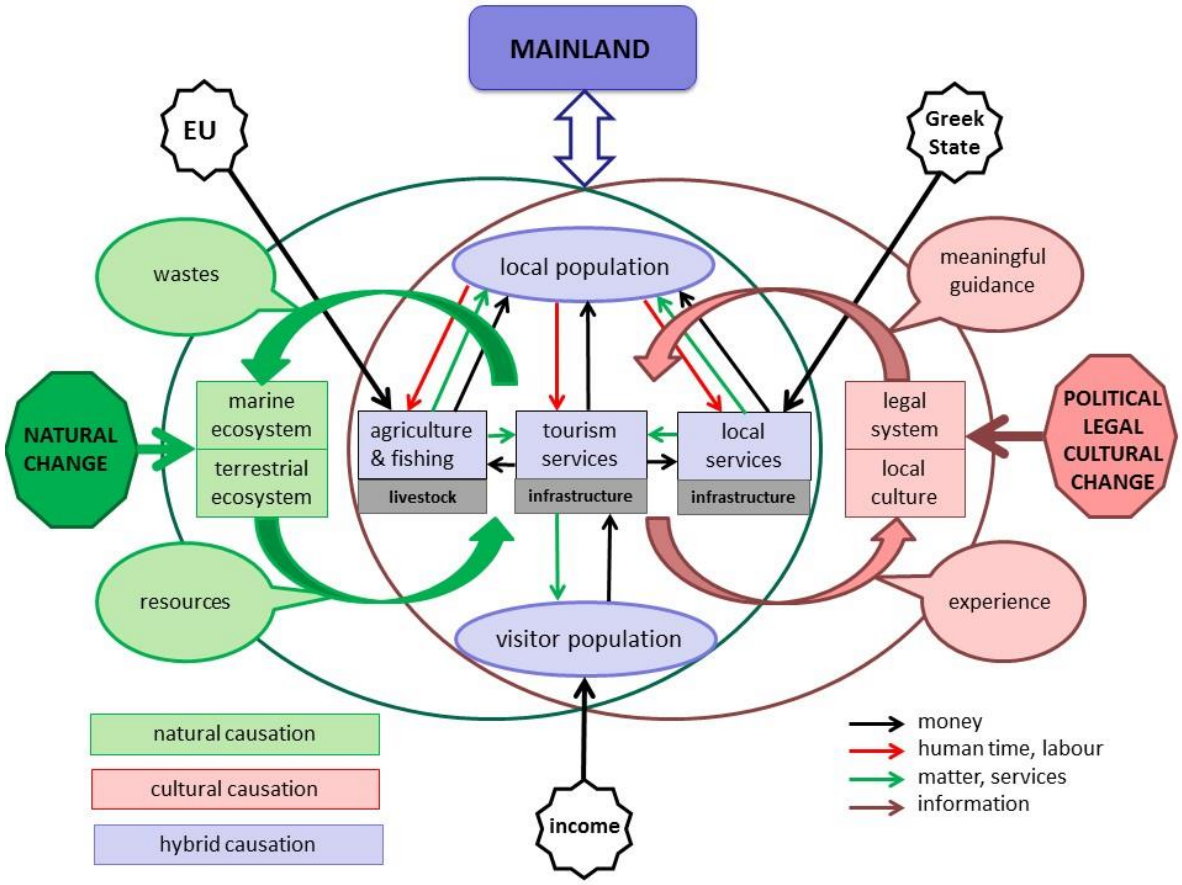

Figure 1: Comprehensive model of the island's socioecological system

The socioecological system of the island also strongly depends on the outside world: there is a lifeline with the mainland, depending on adequate transportation for people's mobility (both local

population and visitors), for imports and exports, for services and for information (the latter nowadays less dependent on physical transportation than in the past). Marine and terrestrial ecosystems, as well as most hybrid structures, are influenced by natural changes (such as climate change), and the island's legal and cultural system is affected by political, legal, cultural (for example religious) and economic changes in the outside world. There are currently three regular major income flows originating from outside: the money the visitors bring with them (as mentioned above), EU subsidies for the agricultural sector, and the payments made by the Greek state for local services (such as the communal administration, schools, medical services, energy services, public transport and public infrastructure)[2].

The ability of any socioecological system to reproduce itself relies on the interdependencies of its stocks and flows. When critical stocks cannot be reproduced the system collapses. Societal metabolism needs to operate between certain margins: A high metabolic profile, and the subsequent path dependencies, can lead to an unsustainable use of natural resources and a degradation of the resource base. Likewise, a too low metabolic profile (relative to the rest of the society of which the island is part) may lead to inhabitants leaving the island for more prosperous parts of the country, thus inducing a breakdown of certain basic institutions (e.g. family support systems, schools, health services) and eventually put the local society into a downward spiral of unsustainability. So on the one hand there exist some more obvious ecological/biophysical tipping points, such as the overuse of resources, that if crossed can lead to ecological collapse. Overfishing, deforestation and massive erosion following overgrazing are examples for this. On the other hand, there are some social tipping points that if crossed can lead to societal disintegration and collapse and finally to the die out of the local population. For example the maintenance of a school: If a local secondary school cannot be maintained, this would force young parents to withdraw from the island, which in turn would threaten caretaking of the old who would therefore also have to leave the island, and a substantial decline in local population would ensue.

These issues known from "dying rural peripheries" are even more pronounced on islands that face more stringent limitations, or inefficiencies. Bussing children to school in a neighbour community may be an option, but shipping them regularly across the sea is not. Thus tipping points become more critical, and if crossed can lead to a mass abandonment of the island. In the words of Deschenes and Chertow (2004: 204), "*the island context shortens the planning horizon over which sustainability concerns become important*". While in agrarian societies of the past the fertility of the land and protection from raids may have been critical for sustaining the local population, in modern society a critical level of sociometabolic standard and complexity counts[3].

We intend to operationalize the system compartments and flows as pictured in figure 1 and generate, as far as possible, quantitative estimates for the physical and monetary flows. We will then attempt to link them in a formal model simulating the system dynamics. Subsequently, we will explore the

[2] There is also a return flow of taxes from the island, but here we assume there is a net balance of public monetary flows to the island.

[3] A recent study (PLANISTAT, 2002) identified a population of 4 to 5 thousand people as a key threshold for the provision of an important part of services locally. This still does not include "superior services" (e.g. hospitals, tertiary education, cinemas, etc.); for those one must travel to a larger urban centre (Spilanis et al. 2012).

option space for sustainability and use qualitative methods to find out if in a situation of crisis cultural change towards collaboration and self-empowerment may occur and widen the range of possible solutions.

3. State of the art

The project draws from and builds upon different streams of research, namely on socioecological systems, societal collapse, and system dynamic studies on islands. Each of those is briefly presented below.

3.1 Socioecological systems and Long Term Socio-Ecological Research (LTSER)

In assessing the development trajectory of a socioecological system and exploring transition pathways towards a more sustainable future, one need not only account for biophysical flows, but also understand the changes in the social structure that support these flows. The concept of social metabolism (Haberl et al. 2004) is a step in this direction. Its inherent strength lies in incorporating both the natural and social systems and focusing on the interaction between them, in particular on the social activities which have a direct material impact on the ecosystem. The sociometabolic approach takes society as the unit of analysis, interpreted as a socioeconomic system that interacts with systems in the natural environment. Society is conceptualised as a hybrid between a natural (biophysical) and a cultural (symbolic) sphere of causation (Fischer-Kowalski and Weisz 1999), each obeying to a different logic. At the intersection of the two we find the biophysical structures of society: that is humans, their livestock and durable infrastructure (as in figure 1).

The social metabolism approach is inherently coevolutionary (Sieferle 2011). Coevolution suggests that if technologies, values, institutions and knowledge change, "*in the process they transform environments, both materially and cognitively, but in turn are transformed by the environments they produce*" (Norgaard and Kallis 2011: 293). It is a coupled development in which human practices both modify the biophysical environment, and are shaped by it; humans transform their natural environments and then adapt to the transformations (Godelier 1986, Norgaard 1994).

Concerned primarily with questions of socioecological sustainability, the emerging interdisciplinary field of Long Term Socio-Ecological Research (LTSER) aims to observe, analyse, understand and model changes in coupled socioecological (or human-environment) systems over long periods of time (Haberl et al. 2006, Singh et al. 2013). This project will deliver data which later could help in establishing an LTSER platform on Samothraki, addressing the social metabolism and land use in historical times and its development over the centuries in a close collaboration between archaeologists, social ecologists and land use scientists - the goal of this being to outline a medium-term research plan and bring together the potentially interested parties. This will draw on international approaches to LTSER

development as outlined in the recently published state-of-the-art compendium on LTSER edited mainly by colleagues at SEC (Singh et al. 2013).

3.2 Complexity, sustainability and collapse

Tainter (2011) distinguishes collapse from other transitions by defining it as *the abrupt reduction in complexity*. *Socio-political collapse* is therefore defined as a rapid simplification, the loss of an established level of social, political, or economic complexity (Tainter 1988, 2006a, 2006b). This resonates with other prominent definitions like the one from Diamond (2005: 3) who defined collapse as "a drastic decrease in human population size and/or political/economic/social complexity, over a considerable area, for an extended time". What drives collapse? In Tainter's view collapse occurs when the level of social complexity cannot be sustained anymore, as the costs of complexity exceed the benefits. Ecological overshoot is another popular theory as a cause for civilizational collapse (Chew 2001). Diamond (2005) constructed a framework of environmental factors, climate change, hostile neighbours, friendly trade partners and societal responses. Moreover, Greer (2008) in his theory of catabolic collapse, describes the breakdown of complex societies as the result of a self-reinforcing cycle of decline driven by interactions among resources, capital, production, and waste.

Following the sociometabolic approach, we conceptualise collapse as a situation in which social metabolism ceases to function properly, i.e. cannot maintain the existing societal stocks (population, livestock, infrastructure and artefacts – see Fischer-Kowalski 2009). Referring to a socioecological system, or more precisely a socioeconomic system with ecological hinterlands, collapse occurs when one or more subsystems cannot reproduce themselves any more. Complex systems may have several *tipping points*. Sometimes referred to as critical transitions or catastrophic thresholds, these are points at which a system shifts abruptly from one state into another (Scheffer et al. 2009). This may happen when the ecological resilience of a system is exceeded (Briske et al. 2010), or can be triggered by social stressors, such as demographic, economic governance or environmental-perception factors (Dearing et al. 2010).

3.3 Systems tradition in island studies

The defining feature of islands – their very "insularity" or better "islandness" (Baldacchino 2006) – provides them with some fairly distinct features, broadly categorised as issues of scale and issues of isolation (Kerr 2005). For ecological science, islands are particularly useful model systems because they have clear physical boundaries, cover delimited geographic areas and are governed by driving forces that can be disaggregated and experimentally controlled. Yet, in a modern, interdependent world, these same properties present island populations with the challenges of limited resource availability, tenuous resource security, and limited natural carrying capacity (Deschenes and Chertow 2004). Thus, populated islands typically have fragile ecosystems and economies, are heavily dependent on imports for a broad range of goods, and suffer from size constraints in the development of resilient water, sanitation, energy, and waste

management systems. This makes islands excellent focal points for studies that systematically analyze the interactions between human activities and the environment, in an attempt to move toward systems and practices that are sustainable in the long-term. Industrial ecology studies for example explicitly model flows of materials and energy at the island system level, using the analytical results to offer recommendations for sustainable practices (e.g. Sundkvist et al. 1999, Eckelman, and Chertow 2009).

Former modelling approaches on island socioecological systems include an integrated dynamic model linking economic development and the natural environment in the Greek Sporades islands (van den Bergh and Nijkamp 1994). In the same year, Lutz (1994) published the International Institute for Applied Systems Analysis (IIASA) Mauritius model, also called the population-development-environment (PDE) model, an attempt to integrate the dynamics of key developmental parameters within the constraints imposed by resource allocation and environmental degradation. Erickson and Gowdy (2000) used a modified Lotka-Volterra predator-prey model to examine the relationship between natural resource systems, human-made capital, population growth and institutional change, comparing Easter Island to the island of Tikopia. They show that population control and natural resource conservation have been essential for long-term sustainability and cultural norms and institutional change can be pivotal for achieving this.

Efforts have also been made to apply sociometabolic approaches in an island context in order to explore the dynamics of socioecological transition at a local (island) level and the consequences this may have for sustainability (Singh et al. 2001, Singh and Grünbühel 2003). More recently, Nguyen et al (2011) following a systemic approach, attempted to model the components and interactions between the policy, social, environmental and economic dimensions of the Cat Ba Archipelago Vietnam, a UNESCO Biosphere Reserve. The resultant model has been used to identify key leverage points for systemic interventions that will be most effective. This was an effort to operationalize the recently coined concept of Biosphere reserves as "Learning Laboratories" (Ishwaran et al. 2008). Moreover, Wildenberg and Singh (2012) presented a multi-level model of the socioecological system of Kamorta island, in the Nicobar island Archipelago, in order to better understand the complex impacts of the 2005 Tsunami, as well as post-tsunami development efforts. In order to incorporate both the natural and cultural "spheres of causation", an agent-based model was combined with input-output models of selected socioeconomic and ecosystem components.

Chertow et al. (2013) provided cross-cutting reflections on human-nature interactions based on the examination of four islands: Singapore, Puerto Rico, Hawaii and O'ahu Islands. Over the course of the twentieth century, each of these islands became heavily dependent on imports such as water, food, and/or fuel to sustain basic human needs and modern economic functions. Within the last decade, each has consciously sought to restructure its socioecological configuration by using more locally available resources in one or more of its metabolic cycles. Chertow et al. (2013) showed that the islands' socioeconomic borders are not fixed, but rather change with perceptions, economic relations and political decisions, and moved on to differentiate between tightly and loosely coupled socioecological systems. Tight coupling (between the social and the ecological compartments of the system) becomes looser when

resources are imported from faraway places, and coupling is mediated and influenced by global markets, institutions and governance structures, in a process where non-material changes influence material flows.

4. Samothraki: description of the research site

4.1 Main features

The island of Samothraki is among the rare remaining examples of "natural" island beauty in the Greek Aegean archipelago. It is situated at the North-eastern point of the Aegean Sea, very close to the border with Turkey, not far from the mouth of the Dardanelles (*figure 2*), on the route from the Black Sea to the Mediterranean. It has been inhabited since prehistoric times, as proven by the numerous prehistoric sites dating back to 6000 BC. From about 2600 BC until 400 AD, Samothraki was famed as a spiritual centre, with its 'Sanctuary of the Great Gods' devoted to the cult of Kaveiria mysteries. The remains of this sanctuary have been unearthed during the last two centuries (the famous statue of Nike in the Louvre Museum originates from Samothraki), and together with the local archaeological museum today constitute major tourist attractions. During Byzantine and Ottoman times the island played an important role in maritime trade, the evidence of which can still be found in the picturesque remains of towers and fortifications.

A large part of the island's total surface area of about 178 km^2 is mountainous, owing to volcanic origin, with the highest peak rising up to 1611 m. Due to the orientation of the mountain range, a wet microclimate exists on the north side, with numerous streams coming down from the mountain, forming hundreds of waterfalls and scenic freshwater ponds. There are also thermal water springs renowned for their health benefits since antiquity. Lush vegetation shaded by century-old oriental plane trees reaches down to the beaches. The southern and western sides are typically Mediterranean in terms of climate, vegetation and agriculture: olive groves, wheat fields and vineyards dominate the landscape.

Samothraki has so far escaped mass tourist development.[4] The reasons for this are its remote location (it can only be reached by a two-hour ferry trip from Alexandroupoli, the easternmost city on the Greek mainland), the pebbly nature of most of its beaches, and the fact that much of the land ownership on the island is legally contested (buying large areas for tourism development projects has proven difficult and fraught with legal problems). Almost three-quarters of the island's terrestrial area have been protected under the EU's *92/43 EEC Habitats Directive* (Dimopoulos et al. 2005, Greek Biotope/Wetland Centre 2001). In 2009, the *Natura2000* area was extended by 50 km^2 of territorial waters, which has ushered in a new era of marine research and protection.

[4] With 0.5 tourist beds/inhabitant, Samothraki is in the lower range of Greek islands (Spilanis and Vayanni 2004).

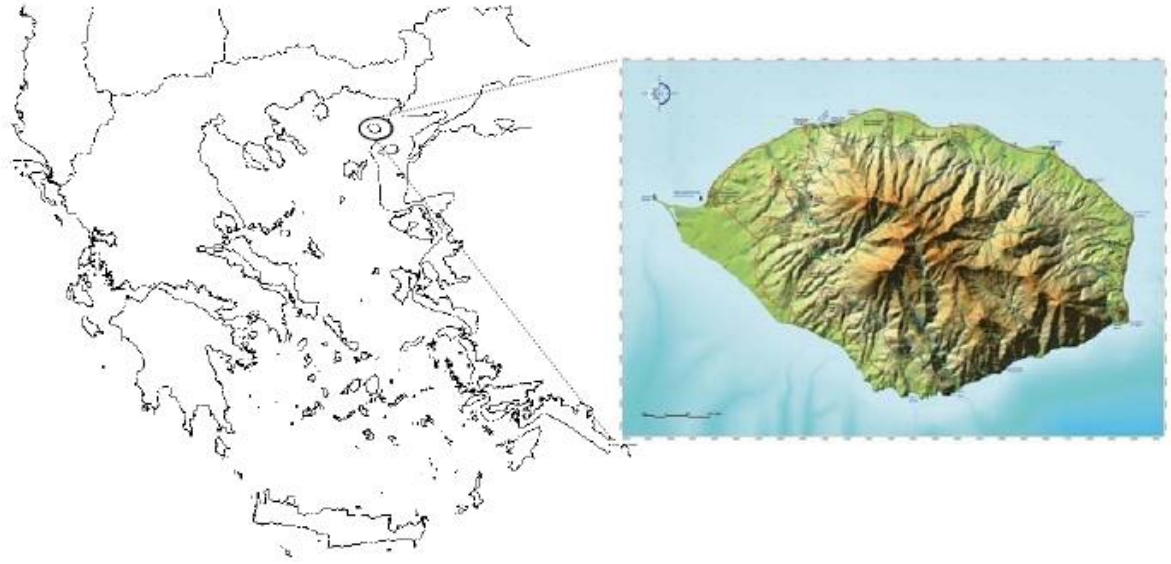

Figure 2: The Greek island of Samothraki and its location within the Aegean Sea (source: Google Earth)

However, there are substantial threats to ecosystems mainly from overgrazing by goats and sheep. At the moment there are around 50-80,000 goats and sheep grazing freely on the island[5], where the carrying capacity is estimated at 15,000 (Greek Ministry of Agriculture 2008, Skapetas et al. 2004). Large areas, including the area protected under *Natura2000*, have suffered erosion. Increasing, largely unregulated freshwater extraction is depleting the rivers and draining the estuary areas that are particularly important for biodiversity. Finally, trawling and driftnet fishing threaten marine species and habitats that are already in decline in the Mediterranean. Although conservation efforts have led to legal protection measures, the degree of enforcement is rather low, and environmental pressures mount (Petridis 2012).

4.2 Current socioeconomic conditions

The island's resident population is in decline, having dropped from a peak of 4,300 people in 1951 to 2,800 in 2011 (census data). A first wave of decline had been due to labour migration in search of income and a better future in the 1960s, in particular to the region around Stuttgart in Germany (Kolodny 1982, Malkidis 2008). Even nowadays, there is a vibrant Samothrakian community in Stuttgart who visit the island during the summer months, and often still have voting rights on the island. As a result, many people speak German and have acquired a certain ecological awareness that in their view contrasts to Greek traditions. This is particularly relevant given that more than 60% of the resident population have received no more than primary education (2001 census), while 9% have a university background.

The primary sector – consisting of agriculture, animal husbandry, and fishery – still employs 41% of the active population. Agricultural land occupies around 16% of the total island territory and the main products are grains, olives, grapes and horticultural products. Agricultural production strongly depends on

[5] Estimated from the official number of annual slaughtering statistics. Distance sampling by social ecology students in October 2012 led to an estimate of 51 000 goats and sheep (Petridis et al. 2013).

subsidies according to the European Common Agricultural Policy (CAP), most of which is expended on the livestock sector (mainly sheep and goats: representing € 1.7 million subsidies annually). These subsidies have contributed to a sharp rise in the number of livestock in the past decade. Local fisheries recorded a catch of 2,186 tonnes (in 2007), estimated to be worth 9.27 million Euro (Greek Ministry of Agriculture 2008, National Statistical Service of Greece 2005). The secondary sector, employing 12% of the active population, is relatively small. There is one olive press, a municipal wheat mill, a small winery, a cheese factory, several bakeries, and some construction and mining activity. The tertiary sector, mainly trade, services, and tourism, has grown substantially during the last decades and now amounts to 40% of the island's workforce. Beyond direct tourism-related services, there are a number of young, well-educated people successfully making a modest living on the island from artistic and performance activities. A substantial number of young people having acquired higher or university education abroad would like to return home if they could find some income opportunity on the island.

According to the socioeconomic data, the resident population is fairly polarized: on the one hand, there is a large group of predominantly middle-age male farmers and herders with low education leading a traditional life with little contact to outsiders and high dependence on subsidies and state welfare programmes. Their income is rather low and their life is often based upon directly utilizing ecosystem services. On the other hand, there is an educated part of the population working mostly in the service sector, tourism and administration, with more contact to the outside world, who perceive the "specialness" of the island either as backwardness and an obstacle to better income, or for the most part as a precious feature that has to be preserved and improved upon.

The island is estimated to receive about 40 000 visitors annually (own data). Of these, about three quarters are in fact tourists. The remaining are family visitors, second home owners and seasonal workers. Almost 40% of all visits to the island happen in the months July and August. In relation to 2,700 permanent inhabitants, visitors appear to be a large number, but on average they stay only for about ten days. On an average day across the year, there are twice as many residents present than visitors, while in the high season, there are twice as many visitors than residents. Still, even in the high season, tourists in the narrow sense amount to a daily average of no more than 3,300. The population density remains very moderate at an estimated 13 persons/km^2 in the off-season and 45 persons/km^2 in the high season.

Tourists, estimated at about 27,000 people annually, are predominantly Greek, well-educated (two-thirds having university education), relatively young (three-quarters are below the age of 40), and more than half of them camp (own data). Half of them have travelled to Samothraki repeatedly, and more than 90% declared an intention to come back in the future. Such an attached tourist population is an important asset for the island. However, almost half of the tourists come in the peak season (July/August), staying there for little more than a week. According to port statistics, there has been no tendency to extend tourism into spring or autumn, and the overall number of tourists has remained stable in the last decade[6].

[6] A reported decline in tourists in the years following the 2008 Greek government-debt crisis needs to be empirically confirmed.

The financial turnover from tourism is significant. Based on our visitor survey and interviews, we estimate the average daily expenditures per visitor at 37 to 46 euros. Annually, visitors spend 16 to 20 million euros on the island. Although the campers spend half as much per day as those who stay in hotels, the overall contribution of both groups is nearly the same, mainly because campers on average stay longer. In this sense, campers are highly relevant for the local economy while exerting the least environmental pressure in terms of infrastructure demands.

5. Work Plan, Methodology and Time Schedule

The project is planned to run through a period of 36 months. The tasks are divided into six main Work Packages, listed below in detail. Figure 3 below provides a graphical representation of the interconnections between the Work Packages. Figure 4 illustrates the work plan.

WP1: Archival work

Scan and review of available data:

- Literature review, exploring factors that build up societal complexity, incl. threats to complexity.
- Scan official reports, as well as scientific and popular documents in order to reconstruct the ecological, socioeconomic and legal conditions of Samothraki during the past decades, including historical records of the late Ottoman period.
- Data mining of statistical accounts on the island's demography, material and energy flows.

WP2 & WP3: Reconstructing Samothraki's Socioecological System

We focus on the current socioeconomic system of Samothraki and the domestic environment where it is embedded (figure 1), breaking it down to its various subsystems and identifying the interrelations between them (and also potential links to other socioecological systems). We intend to operationalize the system compartments and flows as pictured in figure 1, focusing on key linkages: metabolism, labour and – as far as possible – monetary flows. A series of interdisciplinary methods will be used to generate data:

- Ecological/Land-use methods (*WP2*):
    - Estimation of livestock densities in different area types by distance sampling, in order to estimate effects of overgrazing.
    - Line transect methods and angle count sampling to assess tree regeneration and species composition respectively, for different forest types
    - Dendroecological characterisation of forest stands for assessing disturbance histories
    - Data on terrestrial and marine biodiversity will be used from past surveys.

- Sociological methods (*WP3*):
    - In-depth interviews with key persons regarding the imminent inclusion of Samothraki in the World Network of Biosphere Reserves.
    - Focus group interviewing with local stakeholders (such as fishermen, farmers, local professionals, school teachers and others).
    - Deliberative visioning/backcasting workshops with local stakeholder groups.
- Socioecological methods (bridging the above, *WP2&WP3*):
    - Estimate the current social metabolism of the island in terms of material/energy stocks and flows.
    - Reconstruct the sectors of the island's economy in biophysical terms, using public statistics (on population, the economy, tourist numbers and behaviour and land use) and complete the data-set by interviews with locals (such as with farmers and a local cheese factory on the livestock cycle, with the public administration on construction activities, with the local gasoline station on fuel sales etc.) and by observation.

The two main cross-cutting themes to be tackled in both **WP2** and **WP3** are:

a) Tourism / Role of island visitors

Tourism brings benefits and costs and can be seen as problem solving (provide opportunities) as well as problem creating (environmental degradation). Tourism on Samothraki during the last decades has revitalised the island and saved it from population collapse. However, more visitors require more infrastructure thus may constitute a threat to nature conservation goals.

b) Agriculture and land use

Agriculture feeds the population, but demands substantial labour and causes environmental problems / sustainability issues. A reconstruction of the agricultural system will reveal possible system imbalances that affect the vulnerability or robustness of the system under study. For example, according to a preliminary study on the livestock system (Fuchs 2014), reducing animal numbers per farmer by 50% would result in an increase in farmers' net income and a reduction of farmers' labour time, while reducing overgrazing pressure and allowing for better animal health, as well as marketing opportunities (branding).

WP4: System dynamics model

Using data generated, we intend to build a formal VENSIM system dynamics model for making future scenarios about potential tipping points in the system. The model stays in the tradition of Jay Forrester's method coined at MIT in the 1950ies. In 1972 it became globally famous from the report "Limits to Growth" to the Club of Rome. System dynamics uses nonlinear differential equations that are approximated by difference equations on the computer. Such a model should be able to reproduce past dynamic behaviour of the main variables of the system investigated, but it can also be used to simulate their future development under certain conditions. It is based on stock and flow variables which are frequently empirically available in actual socio-economic and ecologic systems.

The specificities of the model will be decided upon depending on the breadth and quality of the data generated, in direct consultation with project advisor Peter Fleissner. The main idea here is to produce scenarios for the future of Samothraki (e.g. collapse, business as usual, sustainability transition), and in each of those identify the potential tipping points, using both demographic and ecological variables (population, income, land degradation etc.), as those will be identified in WP2 and WP3. The results will in turn feed into WP5, where conclusions and recommendations for the future of Samothraki will be formulated. The model should help to answer questions like: What would happen if EU subsidies come to an end? If the population of goats doubles/halves?

WP5: Overarching conclusions for island sustainability and collapse

In WP5 we should be able to draw general conclusions on the following:

- *Consequences for the case*: What are the implications for the future of the island of Samothraki? What is the role of shared beliefs and collaboration? How does this build up, and what causes it to disintegrate? How does a functioning division of labour come into being, how can it be governed? What role does a feeling of shared identity and "specialness" play within the island population?
- *General conclusions, contributing to a theory of sociometabolic collapse on islands*: What appear to be key conditions for sustainability/resilience of island communities? What, on the other hand, triggers collapse?

We are planning to organize a scientific symposium on-site at the beginning of the 3rd year, to present interim results and invite a debate between scientists and local stakeholders. For this, we intend to invite the members of the International Science Board for Samothraki's Biosphere Reserve (10 internationally renowned scientists).

WP6: Video Documentary

The transdisciplinary approach of the proposed project goes beyond basic research of analysing society-environment relations on Samothraki, and aims at achieving a practical outcome, namely support the local community in their effort to place the island on a path towards a sustainable future by "transforming" it into a UNESCO Biosphere Reserve. Along these lines, we plan to produce a full length video documentary complementing the theoretical insights produced by documenting socioecological research in practice. Over a period of three years a film crew will follow the work of the research team on Samothraki and document impressions of the site and its people, insights on interdisciplinary research in action, as well as the dynamic interaction between researchers and the island community. The added value of this WP is manifold:

- Support the research by providing audiovisual recordings of the focus group interviews, enabling a more in depth analysis of the discussions.
- Strengthen communication between the research team and the local community and empower local initiatives.

- Increase the visibility of the project and facilitate the dissemination of project outcomes nationally and internationally, within academia but also to related communities worldwide.
- Render scientific insights more accessible for non-scientists and provide visual educational material.

The output would be of interest to a wide range of audiences: sustainability science scholars and researchers of relevant disciplines, schools and teachers in the field of environmental education, but also the general public interested in positive narratives of cultural and social change.

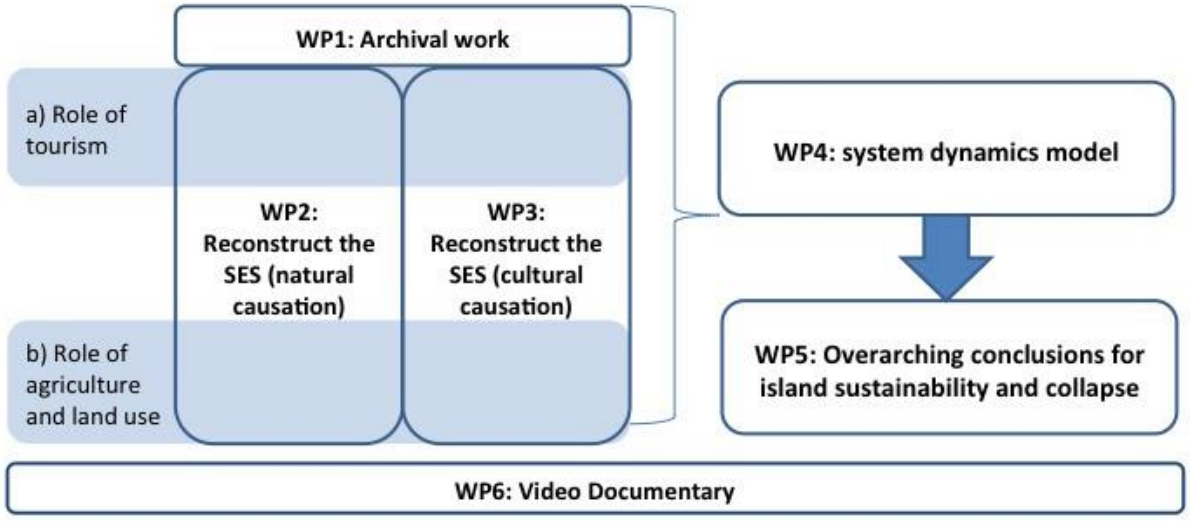

Figure 3: Graphical representation showing how the five Work Packages interrelate

Work Package / Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WP 1 - Archival Work																																				
WP 2 - SES nat. caus.			*				W				X			*						W				X		*					*				X	
> ecological data																																				
> metabolism																																				
WP 3 - SES cult. caus.			*				W				X			*						W				X		*					*				X	
> focus groups																																				
> metabolism																																				
WP 4 - SD model																																				
WP 5 - Conclusions																																				
> on-site symposium																																				
WP 6 - Documentary																																				

(*) trips to Samothraki, (W) Workshops, (X) tentative conference dates

Figure 4: GANNT chart, illustrating time plan of Working Packages

6. Expected outcomes, relevance for other disciplines and future applications

- Operationalization of the system compartments and flows as pictured in figure 1 and generation, as far as possible, of quantitative estimates, paving the way towards a more formal model that could also be used for other cases.
- With regard to the present, concrete recommendations about the role of cultural change (e.g. towards collaboration and self-empowerment) to avoid collapse situations.

- 3-5 publications (exact topics TBD). Publication outlets: *Ecology and Society, Ecological Economics, Society and Natural Resources, Island Studies Journal*.
- This interdisciplinary project will link data from various fields, and we are expecting to contribute to the development of newer fields including LTSER and island studies. As a case study we will also be providing new information for studies of collapse and tipping-points. Other fields our outcomes will be relevant for are e.g. industrial ecology, sustainability transitions and UNESCO-MAB.

7. Human Resources

Univ.-Prof. Dr. Marina Fischer Kowalski received a PhD in sociology from the University of Vienna, but later involved in interdisciplinary work, founding the Institute of Social Ecology in Vienna, and becoming professor of Social Ecology at the Alpen Adria University. She is currently president of the International Society of Ecological Economics. She is member of the MAB Committee of the Austrian Academy of Sciences. Recently, she received an Honorary Citizenship on the island of Samothraki, Greece, for her efforts to found a Man-and-Biosphere Reserve there. She will be the leader of the project. She will be responsible for coordinating the Work Packages, assure the quality of the research as well as help with networking among the team, the island's and other relevant Greek authorities, and UNESCO.

Postdoc-Ass. Dr. Simron Jit Singh is a social/human ecologist and works on theoretical, analytical and empirical aspects of society-nature interactions within the framework of sustainability science and the development discourse. His main focus is in understanding the metabolism of local rural systems and their long-term dynamics using biophysical variables such as material and energy flows, land use, and time-use. He has undertaken extensive fieldwork among the Nicobarese of the Nicobar Islands, India. He will support the research as an advisor, being an expert on island studies and leader of former research projects on Samothraki.

Mag. Mag. Panos Petridis holds a Bachelor and two Master degrees in biology, from the Universities of Bristol, Edinburgh and Plymouth (UK). Currently, he is a researcher and doctoral candidate at the Institute of Social Ecology in Vienna, working on issues of island sustainability and protected area management using Samothraki as a case study. He will be a principal investigator within the project leading WP1, WP3 and WP5. The project will contribute to his ongoing PhD project on "Outlining a sustainable future for the island of Samothraki (Greece) as a Biosphere reserve".

N.N. There will be a PhD opening from the large pool of Social Ecology graduates or equivalent, to work alongside Panos Petridis, as a principal investigator of WP2 and WP4, i.e. focusing on the "natural causation" of the socioecological system analysis.

O.Univ.-Prof. DI. Dr. Peter Fleissner retired from his chair (Design and Assessment of New Technologies) at the University of Technology, Vienna, in October 2006, after seven years of work for the European Union. Before, he had worked for the Austrian Academy of Sciences; for the International Institute for Applied Systems Analysis, Laxenburg, Austria; as research scholar at the Massachusetts Institute of Technology; and at the Institute for Advanced Studies, Vienna, Austria. He will serve as an advisor for the project, supporting the formation of a system dynamics model (WP4).

Ao.Univ.-Prof. DI. Dr. Georg Gratzer is Director of the International Mountain Forestry, Graduate Program, Institute for Forest Ecology, Austrian University of Life Sciences and Natural Resources (BOKU), Vienna, Austria, specialising on mountain forest ecosystems. His research focuses, among others, on forest responses to global change and anthropogenic stress, as well as on regeneration ecology. He will support the project, contributing to the forest ecology methods (WP2).

Armin Faymann has been working as a freelance producer, director and photographer since 2001. His track record includes a number of creative short film documentaries, including "*Samothraki – Portrait einer Insel"* - a feature of the cultural life on Samothraki in 2005. Between 2005 and 2011 he directed and produced his ethnographic documentary *FLUC Fluctuated rooms on Praterstern* – which was awarded at the 39th Festival of Nations in 2011 and was supported by Stadt Wien (MA7) and Land Niederösterreich (Kunst und Kultur). His excellent network and connections to the locals on Samothraki will contribute to the successful realization of the film documentary on the research process (WP6).

8. Information on research institution

The Institute of Social Ecology (SEC) focuses on interactions between social and natural systems. The research staff seeks to employ an interdisciplinary conceptual language and methodological tools from both social and natural science knowledge traditions. Main research areas are: social metabolism, land use and colonization of ecosystems, historical sustainability research (LTSER) and sustainability transitions. SEC belongs to Klagenfurt University and is part of the Vienna node of the Faculty for Interdisciplinary Studies. SEC can provide the project with the necessary internet and database access. In addition to that, its library offers about 18.000 books and access to more than 250 journals.

SEC has been conducting socioecological research on the island of Samothraki since 2007 that has been highly acknowledged, including the Sustainability Award 2010 it received by the Austrian Ministry of Science and Research. This research and the simultaneous networking with local NGOs, stakeholders and the communal administration prepared the ground and helped to formulate an application for the status of the island as a Biosphere Reserve unanimously supported by the municipal council and submitted by the Greek National MAB committee to UNESCO, which is currently under review. Some of the main research activities during the last years included:

- Extensive local stakeholder consultations (following Fischer-Kowalski et al. 2008).
- An extensive survey of visitors, their behaviour and preferences and the economics of tourism, in 2018. Results have been published (Fischer-Kowalski et al. 2011).
- A willingness to pay survey in 2011, revealing that 88.1% of respondents were willing to pay a "green" fee of 2€ or more every time they visit the island.
- A student research excursion, in October 2012. A report has been recently published (Petridis et al. 2013).
- A follow-up enlarged student research excursion in May 2014, as part of an Erasmus Intensive Programme, involving students and staff from 5 EU Universities.

(For more detailed information: http://www.sustainable-samothraki.net/).