1 Description of the main project SUSAKI P27951-G27

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

SUSAKI aims at analyzing society-environment relations on the small Greek island Samothraki. It builds upon a sociometabolic understanding of socioecological systems (Haberl et al. 2011) and seeks to explore the factors that cause societies to prosper and sustain themselves on islands and those that lead to collapse. 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 UNESCO Biosphere Reserve.[1] SUSAKI aims at giving scientific support to this process, and has broad objectives to:

- Identify the key conditions of self-reproduction of the socioecological system on the island, 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.

The project is planned for a period of 36 months; it started on July 1st, 2015, and will extend until June 2018. Its total costs amount to € 350 000.-.

The principal investigator of this project is Marina Fischer-Kowalski (em.Prof. at Alpen Adria University, Vienna). Collaborators are Ass. Prof. Simron J. Singh (Waterloo University, Canada), Mag. Panos Petridis (PhD student at Alpen Adria University), em.Prof. Peter Fleissner (formerly at Austrian Academy of Sciences, and Technical University of Vienna), Prof. Georg Gratzer (University of Natural Resources and Life Sciences, Vienna) and Mag. Dominik Noll (PhD student at Alpen Adria University).

Web link: http://sustainable-samothraki.net/wp-content/uploads/2015/09/SUSAKI-Project-proposal.pdf

1.2 Status quo of the research

SUSAKI builds upon previous research activities ongoing since 2007, supported by voluntary work, as well as seed funding by the Austrian National MAB committee of the Austrian Academy of Sciences.

[1] Following a feasibility study and comprehensive consultation with stakeholders from 2008-2011 (see Fischer-Kowalski et al. 2011), 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 who welcomed the proposal but deferred it until a management is established for the local Natura 2000 areas. 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).

Therefore, the research team is already very familiar with local conditions and well accepted among the community.

Meanwhile, the Greek Government is working at establishing a full legal and management status for the two Natura 2000 areas that cover over three quarters of the island's terrestrial area, and have been extended in 2009 by 50km^2 of territorial waters – a precondition for UNESCO accepting the application re-submitted in 2013 for the island to become a Biosphere Reserve. This process will also involve the local population, and it is therefore essential to expand the number of well-informed and competent citizens. This makes up the core of WP 3 of the current application.

One of the most critical aspects of the island's social metabolism is overgrazing by an excessive number of small ruminants, which leads to severe erosion and biodiversity loss (Biel & Tan 2014), but also to the degradation of touristic landscapes and communal infrastructure. Our tentative results show that local farmers have increased livestock numbers based upon incorrect assumptions about subsidies and largely unaware of ecological impacts. Therefore, one of the key strategic goals of the project, as reflected in WP 1 and WP 2 of the current application, is creating awareness among livestock herders and consider their economic interests together with the intention to reduce animal numbers; we believe this can be done best by organically involving them into the research process.

Another key imbalance for the local metabolism is the inadequate waste management. The waste generated by the 3000 inhabitants, roughly doubled by those from around 40000 annual visitors, have until recently been dumped and frequently openly burned. Since a few years the municipality has rented space in a landfill site on the mainland, and deposits its wastes there at high cost. Recently, in line with efforts on the level of the Greek ministry of Environment, the municipality issued an operational plan on reuse and recycling, and more efficient waste management. For this to be effective, a better understanding of the amounts and composition of local waste as well as their potential uses and treatment needs to be built up among the local population and stakeholders. This is subject to WP 4 of the current application.

Finally, our results so far indicate that the long-standing traditions of political clientelism on the island pose an important obstacle on finding collaborative and sustainable solutions. Currently, the critical economic situation in Greece leaves little room for hope on help "from above". On the other hand, a number of young and often internationally trained people have been returning to the island to seek for a livelihood. While 40% of the local population have very little formal education and work in the primary sector, another 40% work in the service sector, well over half of them educated at universities. They constitute an important population segment well equipped for sparking new initiatives. Probing into this potential will be subject to the cross-cutting WP 5.

"Citizen science as a key pathway to achieve effective nature conservation and a sustainability transition on the island of Samothraki." (acronym CiSciSusaki)

2 Goals and design of CiSciSusaki

2.1 Framework conditions

Citizen science strategies complement traditional educational approaches in multiple ways. On top of helping reduce excessive travel from the part of the researchers, they bring about improved outcomes by establishing a joint knowledge ownership with local stakeholders (e.g. Cohn 2008; Tweddle 2013). The current conditions on Samothraki are particularly favourable to the application of citizen science strategies:

- The island currently finds itself at the crossroads of development pathways and at a critical state that calls for change, for a number of reasons. First, the Greek economic crisis has led to a reduction of Greek tourists and their spending on the island - we estimate a reduction of the island's income from tourism between 30-50% compared to 2008[2]. This has a significant effect since 40% of the workforce on Samothraki directly depend on tourism. Moreover, the large increase of small ruminant numbers[3], in particular free roaming goats, has led to severe overgrazing and increasing erosion that threatens communal infrastructure and landscapes of high touristic value[4]. At the same time, changes in the EU Common Agricultural Policy (CAP) and rising feed prices create pressure on farmer's income. Finally, severe cuts of the public administration in Greece have affected the municipality and reduced its room for manoeuvre. In effect, it has become clear for many people that "business as usual" cannot work, but also they do not wait for help "from above". This has opened up opportunities for experimenting on alternative pathways.
- As a result of our longstanding presence on the island, the research team is well known and well received locally[5]. While a general attitude of suspicion towards strangers (even among

[2] According to SUSAKI survey data from ship passengers in 2015, as compared to survey data from 2008.

[3] There has been a 5-fold increase in free roaming sheep and goat numbers since the 1970s, exceeding the grazing capacity of the island 3-fold (Dimosineteristiki Evros 2004; Fuchs 2015). The data were confirmed by our own field research using distance sampling methods in 2012 (Petridis et al. 2013) and again in 2014 in the course of an Erasmus Intensive Programme organized by the Institute of Social Ecology in collaboration with the National University of Ireland, Galway, Lund University, the University of the Aegean and the Autonomous University of Barcelona (unpublished data). See also Hadjigeorgiou 2008.

[4] For example, parts of the only road in the northeast of the island that connects the port with the easternmost beach of Kipos had to be closed down in the summer of 2015, due to damage caused by erosion.

[5] Marina Fischer-Kowalski was awarded "Honorary Citizen of Samothraki" by the Municipality in 2011. Three consecutive Mayors supported the plan to make Samothraki a UNESCO Biosphere, and the respective applications passed the Municipal Council unanimously. Upon invitation by the respective Mayor, each year from 2010 onwards, public presentations of the ongoing research were given at the community's "Cultural Centre", with 50-80 people participating each time. Invitations of stakeholders to focus groups (farmers, fishermen,

the islanders themselves) is fairly common, the team's concrete requests for information, support and participation in activities have so far received very positive responses. We all have learned to tread very carefully, including the many students from various countries of the world that we brought to the island for courses since 2011, and those students from the Institute of Social Ecology that spent time on the island to gather empirical material for their master's theses[6]

- To our surprise, the language barrier between the research team and students on the one side and local inhabitants on the other side was less of an obstacle than anticipated. Locally, there are a number of well-educated young people who speak English; due to labour emigration, there are also many people who spent years in Germany and their children even received their schooling there. Sometimes, we found the language barrier even an advantage: an emotional style of controversial debate is very common, in particular among Greek men; such debates frequently lead to serious conflict and denial of collaboration. The need for translation, or the impediment to converse in a foreign language, can introduce some healthy emotional distance. But of course, the team always encompasses experienced Greek researchers and can make use of excellent local translators.
- After many years of inertia, the Greek Government is now actively pursuing a full legal and management status for the Natura 2000 areas that have been demarcated on the island years ago. This encourages local activity in favour of nature conservation measures, but possibly also in opposition to them. The original design of the Natura 2000 areas had been carried out in a top-down fashion and evoked little public identification with its goals. Small fishermen even found the delineation of the marine extension to the Natura 2000 area to violate their vital interests while being in favour of the companies running the large trawlers. Thus a process of public deliberation of the conservation measures is pending, and well informed and competent citizens would be invaluable in this debate.

tourism entrepreneurs, young parents, elderly and others) usually attracted a substantial number of people and received favorable feedback. Also the response rates to the team's periodic surveys to ship passengers to and from the island were very high.

[6] Nina Fuchs (2015), Nathalie Schwaiger (2016) and Julia Huber (2016).

2.2 Overall design and framing of CiSciSusaki

CiSciSusaki will build upon and extend the research activities performed in WP2 and WP3 of SUSAKI:

- WP 2: Reconstructing Samothraki's socioecological system using ecological and land-use methods, such as distance sampling for the estimation of livestock densities, line transect methods and angle count sampling to assess forest structure and tree regeneration and dendroecological characterization of forest stands.
- WP 3: Reconstructing Samothraki's socioecological system using sociological and socio-ecological methods, such as focus group interviews and visioning workshops with local stakeholders, estimating the island's social metabolism in terms of material/energy stocks and flows and reconstructing the island economy in physical and monetary terms using statistics, interviews and observation.

It should, on the one hand, assist in realising SUSAKI's research goals, and on the other hand empower local citizens to set their own agenda, define their goals and acquire competencies and knowledge to effectively pursue them. For that reason, the work packages and procedures planned in CiSciSusaki focus on some of the most critical issues identified so far.[7]

The research is planned for two years, is fully integrated with the time plan of SUSAKI, and is structured in two phases. In a first *exploratory phase*, extending over a year (summer 2016 until summer 2017), we will probe into all research directions specified in the work packages below, involve local citizens and test the motivation, the feasibility of achieving reliable results, and the organizational measures to be taken to secure efficient cooperation. The experiences of the first phase will be evaluated during a mid-term milestone meeting in 2017 that will involve scientists and local citizens. In a second *execution phase,* we will focus on the activities that had either proved particularly successful, or appear most critical for achieving the research goals of SUSAKI. This phase will also be marked by a meeting between scientists and locals in 2018. Depending on the progress, this second meeting could focus on the farming system, farming income and land use impacts of farming, and also draw in the officers responsible for farm subsidies and agricultural administration. This meeting could therefore indicate a milestone in a transition away from business as usual.

[7] Interestingly, the island of Samothraki has attracted Austrian researchers already since the 19th century. Alexander Conze, an archaeologist at the University of Vienna, made several expeditions to the island and had the ambition to reconstruct the past with a systemic mindset, in contrast to contemporary expeditions from other countries that mainly sought to acquire valuable objects for their museums (see Szemethy 2015).

2.3 Work Packages of CiSciSusaki

WP 1: "Happy goats"

Understanding farmers' choices and engaging them in exploring their economic and ecological options

One of the key sustainability problems identified by SUSAKI was the strong increase of small ruminants on the island during the last decades. This large population of small ruminants threatens both the island's nature conservation goals and its touristic image. From SUSAKI and previous research (focus groups with farmers and the local administration and student work), it had become clear that livestock numbers would only decrease if farmers found more rewarding options to maintain their livelihood.[8] Our findings also point in the direction that livestock maintenance under given circumstances (overgrazing, costs of additional feed, decreasing number of offspring, underutilization of milk and wool, and possibly also of meat) is becoming increasingly uneconomical for the farmers themselves, but in the current economic crisis they see little opportunity for other options (Volanis 2007; Darnhofer 2010; Tzouramani 2011).

WP 1 will apply the Happy Goats web app (http://happygoats.eu/; see also the teaser https://www.youtube.com/watch?v=uH2JJiVxs7k&feature=youtu.be) to a larger sample of Samothraki farmers in order to

a) Better understand the ways in which they see their situation in terms of costs, revenue and production optimisation, and
b) Engage them in addressing other farmers (their neighbours, relatives etc.) and support them in also trying the app to explore their situation, thus creating a snowballing effect.

Responding to the questions of the app is a citizen science approach in itself: the app guides sheep and goat farmers to explore and reconstruct the functional and economic features of their own farm,

[8] This issue was closely investigated by the master thesis of Nina Fuchs (2015) under the guidance of M. Fischer-Kowalski; it came to the conclusion that the rise in livestock numbers could be explained by the way CAP subsidies used to be distributed and had led to an ever increasing amount of additional feed requirements (see also Hadjigeorgiou 2008). The recent changes in subsidy distribution rules and in feed prices as well as the current undernourishment of the animals would make the reduction of animal numbers together with the optimization of their production a rational economic choice for farmers and beneficial for the environment. Building upon this research and the research of the Animal Husbandry Lab of the Aristotle University of Thessaloniki led by Giorgos Arsenos and his team, a collaboration was established between the Institute of Social Ecology (SEC), Vienna, and the Thessaloniki-based ICT firm Integrated ITDC. This collaboration led to the development of the web app Happy Goats, http://happygoats.eu for keepers of small ruminants; a decision support tool designed for them to explore the options in terms of income and labor requirement for their farm, in relation to the number of animals and the use of their products. This app is now being tested and prepared for the market. According to the collaboration agreement between SEC and Integrated ITDC, the software can be freely used in research.

effectively simulating different economic and production scenarios for future years, thus creating knowledge which local farmers are currently often unaware of.

The objective of this work package is twofold. First, to collect data from a larger number of farms on Samothraki to be analysed in collaboration with the partner company Integrated ITDC. Second, to increase awareness and achieve a change of perceptions on the part of farmers, or a relevant fraction of them, via their interaction with using the app.

For this process to be successful (and not to backfire), there needs to be a person or a small group of people on the island that performs app guided interviews[9] in the first round and then monitors the process of snowballing in a second round. The analysis of the results should be done in a collaboration between SEC (that provides the research questions) and Integrated ITDC which can export the outcomes of the interviews as tabbed data and present them in a meaningful format for the analysis required by the project and the local coordinators.

WP 2: "Re-greening"

Exploring ways of re-greening Samothraki and protecting local commons

Over the last decades, the steep increase in the number of goats and sheep has resulted in overgrazing and habitat degradation, with a substantial decline of vegetation cover and biodiversity and an increased risk erosion in areas of steep terrain (Biel & Tan 2014). Moreover, existing infrastructure comes under threat, such as the road along the northern seaside to the attractive remote beach Kipos that in 2015 had to be closed down for cars. Under the given circumstances, there is little money for infrastructure maintenance, making it even more necessary to find ways to protect exposed areas from erosion. There is an urgent need to implement novel agricultural practices that minimize the risk of erosion and promote the sustainability of livestock production, while simultaneously ensuring farm economic viability and biodiversity and landscape conservation.

Within SUSAKI, a one-year experimental effort was undertaken to test a specific type of pasture - Sown Biodiverse Pastures (SBP) - that would reduce the environmental pressure on the island due to grazing and, at the same time, provide various soil and landscape-related environmental services.

The concept of sown biodiverse permanent pastures rich in legumes (SBP) was developed in Portugal over the last fifty years as a strategy to increase grassland productivity and combat soil erosion and land abandonment (Australian Farm Journal 2010). SBP is a system of engineered pastures using

[9] These can be based on the current Field Trials Plan & Questionnaires already established for the Happy Goats app.

biodiversity as leverage for pasture productivity (Teixeira et al. 2015). The main rationale behind this system is the introduction of species specific to semi-arid regions, with the aim of establishing a functioning ecosystem with complementary ecological niches, not only combining conservation and production goals but also offering an alternative for sustainable intensification by combining socio-economic benefits with environmental benefits. The SBP system is based on sowing up to 20 self-reseeding species/varieties of highly productive legumes and grasses originating from Portugal or the wider Mediterranean region, correcting soil conditions by applying phosphorus and/or limestone, and adequate grazing management. The diversity of plants and the balance between grasses and legumes allow a higher resistance to local and climate variability, and the selection of highly productive cultivars ensures a higher productivity as compared to natural pastures. To date, studies have shown a 50-100% increase in productivity in SBP as compared to natural pastures (Carneiro et al. 2008; Teixeira et al. 2010; Teixeira et al. 2011), thereby significantly increasing sustainable stocking rates and providing animals with forage of higher nutritional value and plant digestibility.

In Portugal, SBP has increasingly gained popularity, currently occupying an area of more than 4% of the Portuguese agricultural land. From 2009 to 2014, the installation and maintenance of SBP in Portugal was supported by a governmental fund, the Portuguese Carbon Fund (PCF). This project was managed by Terraprima (www.terraprima.pt), a spin-off of the Instituto Superior Técnico from the University of Lisbon, and it led to new developments in terms of cost-effective approaches to pasture management.

The positive experience with SBP in Portugal suggests that this practice has potential to be successfully implemented in other Mediterranean regions. In Samothraki, in particular, the increasing forage productivity in SBP may allow a reduction in grazing pressure on sensitive mountainous areas, thus diminishing the risk of soil erosion. In addition, it may contribute to biodiversity conservation.

Within SUSAKI, a local citizen, forester by education, has been engaged to collaborate with Terraprima to perform an experiment testing the adaptability of SBP to Samothraki's conditions and to find interested local farmers to provide and prepare their land. Terraprima contributed to this collaboration with its experience in the implementation of soil-friendly agricultural activities and on the best pasture management practices. Four plots with different soil conditions were sown in October/November 2015, and the pasture conditions within these plots have been monitored since then. In spring 2016, an assessment of the development and flowering of these pilot parcels will be undertaken with an emphasis on the agronomic benefits of these pastures.

The next stage, incorporated in WP 2 within CiSciSusaki, should pursue the following goals:

a) Using the recently developed cadastre map of Samothraki and with the help of students and volunteering local citizens, identify areas in local farms with pastures representative of the baseline (the conventional pastures that exist on the island).
b) At the above selected farms implement an experimental design to test the hypothesis that SBP can provide enough fodder to reduce grazing pressure on more susceptible pastoral areas, as compared to the baseline.
c) Test the hypothesis that SBP are more stable in comparison to the baseline as a result of a bioengineered composition that targets productivity and functional complementarity.

The aim of activities (a) and (b) is to expand the implementation of SBP to additional parcels with a long-term (~3 years) analysis of the effects on productivity and plant species composition, in order to evaluate on the sustainability of this agricultural practice. Local partners will be trained in identifying risk prone areas, negotiating with owners, preparing the soil, seeding and monitoring the development and the performance of the Sown Biodiverse Pastures.

Activity (c) will require detailed quantitative assessment of the performance of the SBP experimental plots. In June 2016, a collaborator of Terraprima from the Instituto Superior Técnico, specialist in plant ecology, will perform a detailed quantitative assessment of the effects of implementing SBP on aboveground productivity and species composition at the SUSAKI pilot parcels, for quantification of plant biodiversity and community compositional changes. This will be repeated in June 2017 and 2018 at each of the new parcels sown in (b), in close collaboration with the farmers who devote their land to these trials.

For the monitoring process, a natural pasture in close proximity to the pilot parcels will serve as a baseline. Using the step-point method (at intervals of 1 m), observations along four 100m line transects will be made at peak biomass season (May/June) in each pilot parcel and a nearby natural pasture, measuring total cover, cover for individual species, and species composition by cover. Collected data will enable calculation of diversity (species richness, Shannon-Wiener diversity index, Simpson´s diversity index, Evenness), and similarity indexes (comparison of species similarity between sown and natural parcels, through calculation of the Renkonen similarity index). In addition, in each pilot parcel and the nearby natural pasture, aboveground productivity will be assessed, by harvesting all plant material in four replicate 40x40 cm quadrats. Harvested plant material will be separated by individual species, and analysed for crude protein and crude fibre, enabling assessment of nutritive value and feeding units.

The knowledge gains on the outcome of these experiments will be published (on peer-reviewed journals, proceedings, as well as the website) and can provide a showcase for Mediterranean regions

threatened by overgrazing and erosion. Locally, the most significant dissemination effort will be undertaken with “farm labs”, a cooperative approach to innovation that is in line with the European Innovation Partnership for agricultural productivity and sustainability.

Farm labs aim at inducing farmers to learn practical research skills which they can implement in their own farms. This is an old concept, reconfigured by the Soil Association (see McMillen & Benton 2014) to promote field-based practical innovation through dissemination of knowledge gathered by practical experience. In CiSciSusaki, local farm labs intend to promote dissemination, knowledge transfer and awareness of the best pasture management practices. They will occur at two milestone phases: the sowing of the pastures and the spring monitoring of their performance.

Farm labs will be led by Terraprima, with facilitation from the local coordinators. The farmers that contributed with pasture parcels already in 2015/16 will act as “pioneers” and will coach farmers willing to try SBP. A first farm lab will be held in May 2016, recruiting the farmers for the activities in (b). In fall 2016 these two groups of farms will assess the condition of the pilot parcels and will share their experience with other farmers. This dissemination process will be repeated in spring 2017, fall 2017 and spring 2018. Participants will be recruited using the local radio and personal contacts.

WP 3: “Nature conservation”

Raising public awareness for the value of nature conservation efforts and potential resources for their management by citizens

Samothraki is a unique island unparalleled in the Aegean Sea: it is a Mediterranean island dominated by alpine and subalpine features. It is host to about 1441 different species, 92 of which rare and/or endemic (Biel and Tan 2014), making it an ecological treasure. The island is host to coastal as well as rare mountain wetlands and swamps (headwater or spring swamps). The central mountain ridge is particularly known for its distinct mountain flora. For example, many slopes exhibit a distinct heath type (mountain hedgehog heath) that strongly depends on high precipitation and harsh climatic conditions (wind, temperature, solar radiation). Another unique feature for Aegean islands is the phenomenon of “Abschwemmlinge” where mountainous plants descend into lower elevation areas following large streams (Biel and Tan 2014). Moreover, river features show a high degree of naturalness; lotic, lentic and riparian conditions exhibit significant perennial flows with waterfalls, pools and ancient riparian woodlands (Skoulikidis et al. 2013).

Biel and Tan (2014) show that almost all natural vegetation types suffer from severe overgrazing. The subsidization of olive cultivation and livestock breeding by the European Union has resulted in a drastic

reduction of natural vegetation and a degradation of most plant communities, putting many of the unique features of the island into danger. Macchia, which dominates the lowland landscapes has already been reduced and only 5% of the original mountain wetlands and bogs still exist, the remainder already show signs of degradation. Also, grazing is responsible for the widespread degradation of woodlands, preventing their regeneration.

The uniqueness of Samothraki has led to inclusion of the largest part of the terrestrial area of the island, including around 50 km^2 of the adjoining marine area in the Natura 200 Network, under EU's 92/43 EEC Habitats Directive and 2009/147/EC Birds Directive, largely overlapping (Dimopoulos et al. 2005; see Figure 1. However, there is currently a legislation gap due to the fact that the Natura 2000 areas are not officially designated by a Presidential Decree. The Greek Ministry of Environment is currently undertaking this step and discusses future management options. These areas are of great value for nature conservation and for the island's future as a tourist destination and the partial lack of awareness and recognition of these values by the local population may undermine conservation efforts. A proper long-term management plan for the Natura 2000 areas would also be a central requirement for the establishment of a UNESCO Biosphere Reserve on the island and thus a prerequisite for a core goal of SUSAKI.

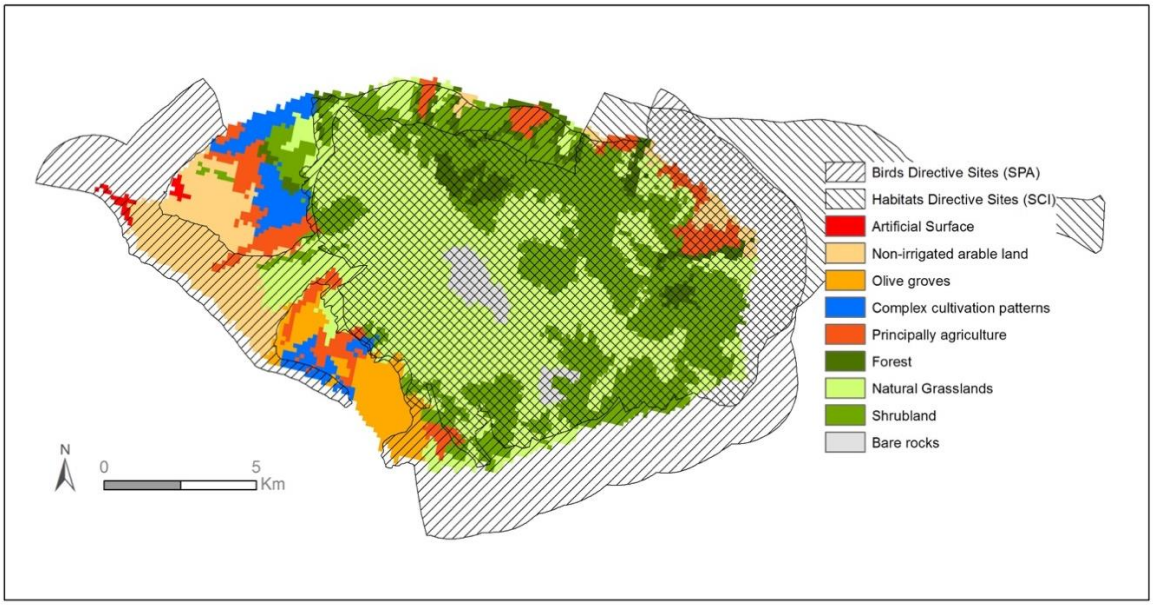

Figure 1: Dominant land-cover types and Natura 2000 areas on Samotrahki island (Natura 2000; CORINE 2015)

The current work package will support local understanding and public awareness of the value of nature conservation in several respects. The objective of WP 3 is to teach local volunteers to implement simple methods to estimate animal density, grass-cover and forest conditions. On the island, most animals roam around freely. This makes local information on animal density an essential precondition for improving grassland management. In addition, ground-cover is an essential indicator of grassland

health, and declining grass cover is related to increasing vulnerability to soil erosion (FAO 2002; MLA 2014). We will focus on training three methods: distance sampling for estimating animal population density, step-point method for the estimation of ground cover, and a combination of line transect methods and angle count sampling to assess forest structure and tree regeneration. They are each described in the following paragraphs:

a) Estimating population numbers of mammals is a common challenge in wildlife monitoring and serves as a basis for wildlife conservation projects. Numerous methods have been developed, with the distance sampling on transects established as a prominent one (Buckland et al. 2005). Line transects are commonly applied to livestock censuses and can be implemented in various ways, ranging from walked line transects, to vehicle based spoor transects or aerial surveys. The latter are most commonly applied to survey large, remote areas. The basic idea of all mentioned approaches is similar: a structure of sampling lines is developed in advance and then followed by one or more observers on foot, car or plane. While executing transects, direct sightings of animals can be documented and measured. If of statistically significant dimension, a calibration of these data with calculated detection rates allows for an extrapolation of total species population data for the area covered. After designing the transects, an observer walks the transects and records all direct sighting distances, herd size (or cluster size), as well as the angle to the virtual transect line. With that information, the perpendicular distance (in 90 degree angle to the transect line) can be calculated, which in combination with cluster size and other transect parameters allows for testing models that finally give estimates on population sizes.
b) To estimate ground-cover of different grassland sites we apply a step-point method as introduced by Evans and Love (1957). This is an easy, rapid and straightforward method for assessing ground cover of grasses, forbs and shrubs (Elzinga et al. 1998, MLA 1999; BLM 1999) by means of point sampling**.** Vegetation or bare soil is observed at each step along 10 to 13 transects of 30m length. This ensures a minimum number of samples of 300 to 500 points, which has been reported to be adequate to provide plausible results in homogeneous vegetation types (Rangelands West 2014). This method is easy to learn, not very time demanding and does not require expensive equipment. A detailed documentation (GPS coordinates, orientation of transects, pictures) will enable local citizen scientists to track the status change of their pasture/grassland and to set action when necessary. Together with data on animal density, this will allow farmers to make better informed management decisions, help to restore already degraded lands and prevent further damage to the natural asset of the island.
c) We will use line transect methods and angle count sampling (using smart phone apps available free of cost) to assess forest structure and tree regeneration, as well as species composition for

different forest types on a substantially larger scale than planned in SUSAKI, by training local volunteers in these methods and engaging them in reporting on selected forest areas.

WP 4: "Circular Economy"

Understanding local waste flows and using citizens' skills to explore potentials for the improvement of Samothraki's waste management system

Island communities often require specific, regionally different strategies to implement efficient waste management (Eckelman et al. 2014). SUSAKI aims at estimating the amount and composition of wastes as a basis for selecting an appropriate strategy for Samothraki. Waste flows also constitute one of the core elements of our efforts at modelling the socioeconomic metabolism of the island. The model presupposes quantitative estimates of various waste flows and their composition in different seasons. It should help to explore potentials for increasing the circularity of the local economy, by increasing end-of-life recycling rates and re-inserting the organic components into the local nutrient cycle (Haas et al. 2016).

In Greece more than 80% of municipal solid waste is being landfilled, with a recycling rate of only 17%, compared to e.g. 59% for Austria in the same year (Eurostat 2016). The Greek national waste management plan of 2015 targets a 65% recycling rate and composting of 40% of organic waste by 2020, by seeking to stipulate a decentralization of waste treatment through separation at the source (Official Government Gazette of the Hellenic Republic 2015). This trend is reflected on the local waste management plan of the municipality of Samothraki that emphasizes a reduction of waste volumes through reusing, composting, recycling and the construction of a small waste management unit on the island itself (Municipality of Samothraki 2015). Studies on waste treatment on touristic islands confirm that despite different regional conditions, the separation of waste at their source and the composting of organic fractions are the main requirements for a cost-efficient waste management strategy (e.g. Skordilis 2003, Chen et al. 2005). Currently, those parts of the waste flows that are collected by the municipality of Samothraki are shipped and deposited to the mainland at fairly high cost. The Mayor has not yet been very successful in convincing the local population that waste separation and recycling would reduce the financial burden on the municipality and free resources for other purposes, benefitting the citizens.

In accordance with the municipal waste management plan, a citizen science approach to this problem will aim at demonstrating the potential value of certain waste streams, elicit creativity concerning alternative solutions, and generate more reliable estimates on local waste flows. The following citizen science approaches will be explored:

a) With the support of teachers, we will make an effort at establishing a local composting site within the school area that could serve as an educational experiment with the students. School children will measure the weekly amounts of organic waste in their households and possibly bring them in small standard containers to the composting site. Under the guidance of their teachers, they could examine how much organic waste is generated at a certain time, what happens to it at the composting site, and how the compost can be used for different purposes in the local environment.
b) Local partners will help to find a group of citizens that would, under scientific guidance, design an explorative study on the fate of glass containers (bottles) on the island, in order to estimate how many are imported, how many are returned to the mainland and how many end up in household waste. A similar approach can be used to track down distribution paths and quantities of metals used on the island. Potentials for a local deposit system will be explored by designing an experiment with local citizens to test if an economic incentive for returning bottles/metals would make any difference and how this could be implemented. After sufficient data is collected, the findings will be evaluated and presented to the municipality, the importers and the Mayor.
c) Another field of exploration, with support from local citizens, will be wool. The roughly 40.000 sheep on the island need to be shorn annually, and most traditional ways of using the wool are hardly employed, while prices on the international market for (ordinary) wool are very low. Thus, most of the local wool is either burnt or discarded. In the course of the project, we aim at reconstructing traditional uses of wool. Another interesting possibility is the production of woolen insulation for houses (this was actually an idea from a local farmer!). We envision a collaboration with Austrian farmers who hold a patent for washing the wool, and would like to encourage local farmers with our help to explore this business potential.

WP 5: "Joint Reflection Citizens & Scientists"

Evaluating Citizen Science contributions to scientific findings, and to public awareness and ability to solve their common problems

This final cross cutting work package aims at providing a unifying framework for all previous activities, formalize synergies with SUSAKI and initiate an iterative process of adaptive decision making. By its very nature, SUSAKI is a truly transdisciplinary research project, as it aims at giving scientific support to an ongoing process of establishing a UNESCO Biosphere Reserve on Samothraki. Such a future horizon for the island opens multiple opportunities for achieving real local sustainable development,

and ensuring the establishment of longer lasting local institutions that would promote and apply more sustainable solutions to local socio-ecological challenges.

In this context, the ambition of CiSciSusaki is to translate scientific research insights in lay terms, but also to achieve real local empowerment and a transfer of the project goals, vision and indeed ownership to the local community. We aim at employing citizen science methods in data generation, agenda setting and investigation, and dissemination, not only to improve the outcome of scientific research, but also to empower citizens to find creative solutions for local problems. Practically, this would mean achieving a proper integration of scientists and local stakeholders, including the commune, and an active participation at all stages, from problem definition and data generation to dissemination.

With WP5, the plan is to intensify and formalize the iterative feedback process between the research team and local citizen scientists followed throughout the project (see Johnson 2014; Kobori 2015). This feedback is designed to (i) inform the local stakeholders of the research findings, (ii) provide a plausibility check for interpretations, (iii) highlight conflicts of interest, (iv) build synergies with already defined municipal priorities, such as the new waste management plan (WP4), and finally (iv) provide guidance to decision makers. This will be supported by a total redesign of the existing SUSAKI webpage www.sustainable-samothraki.net that would play the role of a central information hub and will include news and results, in English and Greek.

At a later stage, we should be in the position to answer the following questions: What do the experiences from the project tell us about the conditions of success or failure of efforts to increase local participation? What insights and lessons learned can be applied to other areas? Which challenges are involved in mobilizing citizens to contribute to scientific efforts? How can conflicts be made productive? These questions will be taken into consideration throughout the project, and explicitly addressed in the agenda of the intermediate workshop that would take place in 2017, as well as on the agenda of the final workshop planned within SUSAKI for 2018. They will also be a subject of a separate publication at the final stages of the project.

3 Overview of citizen science research strategies employed

	WP1: **Happy Goats** – using app to improve farm economy	**WP2**: **Re-green-ing** Samothraki by SBP	**WP3**: **nature conservation**: grass, forest and livestock	**WP4**: **circular economy**: com-posting, recycling & use of wastes	**WP5: joint reflection** citizens and scientists
crowd sourcing	farms as case studies	farmers provide land	collect data on vegetation cover, forest regrowth, livestock density	generate quant. estimates of recyclable components	
distributive intelligence	farmers evaluating scenarios	identify critical areas; annual farm labs to interpret outcomes	analyzing inter-relations, finding explanations (annual workshops)	testing methods to introduce composting and waste collection	better dissemination of results; elucidate contradictions
participatory science	support for adjusting the app	identifying critical local parameters	linking to the ongoing Natura 2000 process	sourcing of ideas on how to intervene	empowering citizens for own creative solutions
collaborative science		develop strategies to change processes	creating public understanding of relevance	can a tourism island attain a circular economy?	synergies with municipal goals; reaching group consensus
transformative learning	finding new options in livestock farming	changing farming processes by insight	respecting the precariousness of local nature	jointly changing waste management, new business	gain ownership of results and processes

4 Organizational and financial considerations

For each work package, there is a scientific supervisor and a local coordinator. The latter belongs to the "citizen scientists" and, in collaboration with the respective scientific supervisor, bears responsibility for the local research process and is actively involved in its design. These persons will also be co-authors of the resulting scientific publications; they have also contributed to the design of the current application. Beyond local coordinators, a number of additional "citizen scientists" will be involved in several roles in all work packages. These roles are considered to satisfy multiple capacities: to learn and teach scientific methods, to bring in local knowledge and experience and gather data, and to be part of a local communication network spreading knowledge and contributing to local decision making.

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