# Transdisciplinary Pathways for Sustainability Transformations – a Sustainability Learning Lab in Seychelles

**Pius Krütli**
**Danny Nef**
**Michael Stauffacher**

## 1. Introduction

The objective of this manuscript is to present the structure, organisation and functioning of a sustainability learning lab in Seychelles (SLLS) as well as lessons learnt from its implementation.

The Seychelles, like other Small Island Developing States (SIDS), face a number of economic, social and environmental challenges (United Nations, 2014; Brigulio, 1995). They are small in size and remote, consisting of a huge number of islands spread over a large sea area, which makes them difficult to manage. They are particularly vulnerable to climate change effects, such as sea level rise and weather extremes like heavy rainfall or drought. In addition, the Seychelles are highly dependent on international (tourism) markets and vulnerable to economic shocks, and they often lack the capacity and the resources to properly manage basic issues (e.g. waste management). Therefore, sustainable development is crucial to the Seychelles and is emphasised in many significant official documents.

Sustainability, on the other hand, remains a fuzzy concept that is subject to interpretation despite the elegant general definition by the Brundtland commission of 1987, which states that development should meet the needs of current generations without compromising the ability of future generations to meet their needs (United Nations WCED, 1987). This is particularly challenging when it comes to assessing the progress of sustainable development (Gibson, 2005). Sustainable development can be understood as a continuous and iterative process of checks and balances for a given project, plan or programme for aligning the effects of an action on a fixed target. As simple as Brundtland's definition sounds, sustainable development remains a complex and often difficult to grasp concept for governments and organisations worldwide. An important step towards improving the comprehensibility and consensus building of the concept of sustainable development was taken with the definition of the 17 Sustainability Development Goals (SDGs) by United Nations Member States. However, trade-offs between the three dimensions of sustainability remained since they are widely unavoidable. The potentially resulting conflicts of interests make it difficult to find sustainable solutions.

In Seychelles, the conflicting interests between conservation and economic development are obvious. Even though 50% of Seychelles' land area is under a protected status (Government of Seychelles, 2011), space is rare, and infrastructure, housing, farming, tourism etc. must compete with areas devoted to nature. However, sustainable development is not only about nature conservation; it allows also for economic prosperity and societal well-being.

One way to promote sustainable development is through a (sustainability) learning lab, which all the relevant and interested units join. Given the grand global challenges, such as climate change, depletion of natural resources, loss of biodiversity, water pollution, food security, population growth and poverty, learning about sustainability is crucial. The concept of a sustainability learning lab in its broadest sense can be linked to the Living Lab notion (see next section).

In the remainder of the manuscript, we present the Sustainability Learning Lab in Seychelles (SLLS) that ETH initiated in 2015. In this article, we briefly provide an overview of its structure, the formats, its organisational form and its players. Waste management is used as a demonstration case of its functioning. We then provide insights and lessons learnt from four years of operation and end with some preliminary conclusions.

## 2. A sustainability learning lab in Seychelles

This section draws from but goes beyond an article that was published in GAIA in 2018 (see Krütli et al., 2018b).

### *2.1 Background*

There is a long-standing collaboration between ETH Zurich and the Seychelles, which started in the early 1990s. The works focused on conservation biology. Considerable research was done on invasive species. At that time, collaboration involved the Ministry of Environment and the Geobotanical Institute of ETH Zurich. While this collaboration led to a number of scientific publications (e.g. Fleischmann, 1997; Edwards et al., 2002; Kueffer, 2010), the results also fed directly into the Seychelles' landscape and habitat management.

In 2015, this collaboration was reinforced and expanded to a variety of sustainability-related topics involving a number of partners (see Table 1). Formally, this collaboration is currently backed by two MoUs between ETH/TdLab and the University of Seychelles (UniSey) and the Ministry of Environment, Energy and Climate Change (MEECC). Project collaboration involves some additional partners as well: the Seychelles National Bureau of Statistics (NBS); the Ministry of Fisheries and Agriculture; the Programme Coordination Unit (PCU) of the GoS (Government of Seychelles) - UNDP (United

Nations Development Programme) - GEF (Global Environmental Facility) environmental programme in Seychelles; the Seychelles Planning Authority; and Non-Governmental Organizations (NGOs), such as S4S (Sustainability for Seychelles).

### *2.2 General structure*

The principal idea of the SLLS is to provide a platform for students, researchers and stakeholders from the public and private sectors and civil society to jointly initiate, analyse, prototype, test and optimise projects related to sustainability. It provides a learning space for all participants, a space for reflection about sustainable development in general and in the context of the Seychelles specifically, and enables the further development of concepts and theories of sustainability. The lab is not restricted to problem analysis; it also promotes solutions and supports the implementation of projects. Teaching is given particular importance because it offers great and, so far, underestimated potential (McCormick and Kiss, 2015; Rosenberg Daneri et al., 2015; Trencher et al., 2016), particularly in developing countries. Capacity building in terms of transformative sustainability is timely and much needed in this context. Furthermore, we follow the guidelines for transboundary research partnerships as stipulated by the Swiss Commission for Research Partnerships with Developing Countries (KFPE, 2018). These guidelines define the way in which such a North–South collaboration should occur. In essence, they hold that collaboration includes joint agenda setting, involves the stakeholders that are affected by the research, enhances capacities, shares data among the partners and applies results.

The SLLS was implemented in 2015 and is still under construction. The concept of the SLLS draws from the notions of Living Labs and Real World Labs. Living Lab is an umbrella term that encompasses activities involving research, implementation, testing/evaluating and optimisation (Liedke et al., 2012). Introduced at the Massachusetts Institute of Technology (MIT) and referring to technological innovation aimed at creating and validating products and services in a collaborative real-world environment (e.g. Eriksson et al., 2005), the living lab notion has gained increasing attention from sustainability researchers (e.g. Evans et al., 2015; Geibler et al., 2013). Reallabore (real world labs), the German counterpart, go beyond the 'product and services' focus of many living labs and have become more popular with German scholars (e.g. De Flander et al., 2014; Jahn and Keil, 2016; Schäpke et al., 2015; Wagner and Grunwald, 2015). Reallabore projects are described as 'hybrids' between scientific object and transformative subject (Wagner and Grunwald, 2015), meaning that they reflect neither a pure scientific nor a pure 'implementation' activity. Reallabore, as Wagner and Grunwald (2015) suggest, may: (a) be embedded in real-world contexts, (b) include co-design/co-production of knowledge, (c) have a focus on sustainable transformation, (d) be context-specific, (e) allow for reflection and learning, and (f) serve as sources for change. Furthermore, a transdisciplinary process understanding of all actors as well as a long-term accompaniment and construction of the research design are central prerequisites for successful and effective Reallabore (Ministerium für Wissenschaft, Forschung und Kunst in Baden Württemberg, 2013). However, it is disputed whether

Reallabore differ substantially from transdisciplinary projects (see next section), or whether the two reflect the same but in different forms, as Jahn and Keil (2016) argue. We use the term 'lab' metaphorically in the broad sense of an inspiring and creative learning space, a nucleus where people meet, share ideas, create new knowledge and support the implementation of transformative (pilot) projects in the context of sustainability.

### *2.3 Transdisciplinarity*

The aim of this section is to give a brief overview of the concept of transdisciplinarity/transdisciplinary research (TD), which we use as the vehicle to propel the SLLS (for a more comprehensive overview of TD see, e.g. Klein, 2013; Hirsch Hadorn et al., 2008).

The term transdisciplinarity (TD) can be traced back to the year 1970, when the first international conference on interdisciplinary research and teaching in Organisation for Economic Co-operation and Development (OECD) countries took place. At first, the term TD was rather abstract, vaguely defined as a 'common system of axioms that transcends the narrow scope of disciplines' (Klein, 2013, p190) though referring to a reorientation of the higher education system towards societal needs (Jantsch, 1972). However, the concept did not receive much attention in the scientific community until the late 1990s (for exceptions see, e.g. Kockelmans, 1979), when it was introduced as a research paradigm and epistemological framework (Klein, 2013) and navigation tool to effectively tackle and solve complex issues and systems (Klein et al., 2001). The latter is particularly important for research related to societal transformations towards sustainable pathways (Klein, 2013). The core of this view is based on the insight that traditional problem formulation (and accordingly problem analysis) is limited by the disciplinary structure of science (Pohl, 2011), and therefore adequate understanding of wicked problems is not possible (Rittel, 1973). However, sustainability issues are often wicked, which means they are difficult or even impossible to solve because of incomplete information, contradictory and competing opinions or changing requirements.

There is no generally accepted theory or methodology of TD. Klein (2013) identified five keyword clusters: the first is still strongly related to interdisciplinarity and includes synthesis, holistic thinking, (disciplinary) boundary blurring etc. as keywords; cluster two, unity of complexity, goes beyond interdisciplinarity but still remains in the science realm, referring to keywords such as uncertainty, non-linearity and heterogeneity; the third cluster highlights a clear shift towards collaboration, participation, etc.; cluster four refers to forms of knowledge with keywords referring to system/target/transformation knowledge, science in society or co-production of knowledge; and finally, cluster five refers to transgressive imperative, which means that disciplinary protocols, truth claims and expertise are interrogated. A slightly different overview separating only four clusters can be found in Pohl and Hirsch Hadorn (2007). TdLab's understating of TD is as a scientific approach both in research and teaching that: (1) starts from a real-world problem (i.e. it is a problem-driven research approach, in contrast with traditional

research, which is very often theory driven); (2) goes beyond interdisciplinarity, as it includes people from outside the academic system in order to jointly shape the research process and co-produce new knowledge; (3) strives to meet the needs of both the realm of practice and science (see Jahn et al., 2012); and (4) intends to create a change.

### *2.4 Formats*

We here briefly present the current formats that form the working vehicles of the SLLS. All of them reflect teaching-related activities, but most of them include a research component. The collaboration with stakeholders is key, and in general each format starts with joint agenda setting or joint framing of the problem (co-design) and includes joint knowledge generation (co-production). For more information, see Krütli et al. (2018b).

#### *Transdisciplinary case study*

The transdisciplinary Case Study (tdCS) is the major format, and as such it forms the backbone of the SLLS. The tdCS is a problem-oriented and research-based teaching activity that aims to meet both the students' learning objectives and the practice partners' needs. This is best achieved by joint problem identification (framing), which is key to our understanding of TD (Pohl et al., 2017). The case study is a seven ECTS-credit (European Credit Transfer and Accumulation System; one ECTS-credit is 30 hours) elective course for master's students at ETH. The students have diverse scientific backgrounds and foci, such as environmental, agricultural, engineering and spatial planning sciences. The tdCS in Seychelles takes place every two years in alternation with studies in Switzerland and is a joint activity of ETH and UniSey students.

The study comprises two stages: a semester phase (14 weeks) and a field phase after the semester (3 weeks). It begins in Zurich in the Spring semester, where ETH students meet every week for half a day. The goal of this phase is to define the research questions, to develop a research plan and to prepare for the field phase. Guided by the general topic, students first engage in a literature review to identify research gaps and fields of interest for themselves as well as the case partners. They explore the problem at hand, its context, potential implications and the stakeholders involved. After approximately five weeks, the students split into smaller groups (1–3 students each) to identify a research question and a work package that fits into the overall problem statement and is coordinated with all the other groups. About halfway through this phase, the students organise a two-day workshop involving stakeholders – here from the Seychelles – in order to validate their preliminary work. During the remaining weeks of the semester, each group prepares a detailed research plan, acquires knowledge about the methods to be applied and plans the field phase. To prepare the field phase, ETH students pair up with bachelor's students of UniSey at an early stage using Skype, email or phones as communication tools.

The field phase is a joint three-week activity of ETH and UniSey students. It starts with a kick-off meeting at the University of Seychelles followed by a site visit

related to the given topic to sensitise students to the issue at hand. The students collect data for about seven days (which involves a huge number of local stakeholders). They spend another three to four days engaging in data analysis, and during the remainder of the three weeks they prepare a report draft. The study culminates in a public event at the end of the three weeks where the students present their preliminary results. A board of approximately ten local experts guides the students through their activities, provides access to stakeholders and validates the preliminary works.As a follow-up activity, volunteer students revise report drafts and combine them into a final report, which is handed over to the partners within six months after the study has been completed.

***Local course***

A local course is meant to be functional for the tdCS in the sense of preparing local students for the joint activities during the tdCS in the following year. This three-week course is designed as an interdisciplinary activity and focuses on system thinking and scenario analysis, which are part of the curricula at ETH but have not been established at UniSey. Classes include approximately 15 undergraduates from different disciplines.

***Master's and bachelor's theses***

Master's and bachelor's theses reflect a third format of the SLLS. The original idea behind this was to complement the activities of the aforementioned tdCS either as preparatory work, for example, to look into particular topics that might provide data that the tdCS could build upon, or to provide more information about certain aspects that the tdCS has been unable to study in depth. However, other master's and bachelor's theses on sustainability-related topics but independent from the tdCS are possible. ETH master's theses are six-month activities, while bachelor's theses at UniSey have a time frame of seven months, in parallel to semester courses.

***Internships***

Internships are a fourth format. Currently, they are a compulsory element of the environmental sciences/engineering curricula at ETH Zurich. Internships allow students to acquire practical experience and to gain insights into a potential professional field after their studies. The internship tasks are to be defined by the local partner and the student and formally approved by a supervisor at ETH or another home university. Local partners can be companies, institutions or administrations, such as the MEECC, that are dealing with environmental or sustainability issues. Supervision is primarily the responsibility of the contracting partner.

### *2.5 Overview of the activities 2015-2019*

Table 1 provides an overview of the previous, on-going and planned activities in the formats mentioned above.

***Table 1**: Overview of activities of the SLLS in chronological order*

| Format | Topic/title | Main partners of ETH | No. of students involved | No. of participants* | Year completed |
|---|---|---|---|---|---|
| **tdCS** | Solid waste management (holistic analysis of the current system) | MEECC, UniSey | ETH: 18, UniSey: 18 | >200 | 2016 |
| **Master's thesis** | Characterisation and evaluation of ecosystem services in the Val d'Endor water catchment area (Mahe) | PCU of GoS/ UNDP/ GEF, UniSey | ETH: 2 | >50 | 2016 |
| **Master's thesis** | Composite indicator framework for household resilience on Mahe | NBS | ETH: 1 | >10 | 2017 |
| **Local course** | Introduction in system thinking and scenario analysis technique | UniSey | UniSey: 14 | >5 | 2017 |
| **Master's thesis** | Agricultural system in Seychelles: characteristics, challenges and embedding in the socio-political context | Ministry of Fisheries and Agriculture | ETH: 1 | >240 | 2017 |
| **Internship** | Different tasks | PCU of GoS/ UNDP/ GEF | ETH: 1 | numerous | 2017 |
| **tdCS** | Solid waste management (collecting/sorting and post sorting activities) | MEECC, UniSey | ETH: 19, UniSey: 14 | >350 | 2018 |
| **Master's thesis** | Sustainability appraisal of a cable car project linking Victoria–Beauvallon, Mahe | Doppelmayr-Garaventa, Austria | ETH: 1 | >200 | 2018 |
| **Internship** | E-waste flows in Seychelles | MEECC, Uni Wageningen (NL) | University of Wageningen: 1 | >50 | 2018 |
| **Master's thesis** | Pathways towards the implementation of an e-waste management system in Seychelles | MEECC | ETH: 1 | >200 | 2019 |
| **Master's thesis** | River design and restoration in Victoria, Mahe | Seychelles Planning Authority | ETH: 1 | >100 | On-going (2019) |
| **Master's thesis** | Requirements for formal and informal planning instruments and processes in Seychelles | Seychelles Planning Authority | ETH: 1 | >10 | On-going (2019) |
| **Master's thesis; Bachelor's thesis** | In prep. | PCU of GoS/ UNDP/ GEF, UniSey | ETH: 2, UniSey: 1-2 | | Start: Oct 2019 |
| **tdCS** | In prep. | Seychelles Planning Authority | ETH: <25, UniSey: <25 | | Start: Feb 2020 |

** in expert's/stakeholder's interviews, workshops, surveys (in most cases face-to-face)*

To date, two tdCS, one local course, two internships and six master's theses with more than 1,300 participants have been completed, and another two master's theses are on-going. Two more master's and one to two bachelor's theses will start soon, and a third tdCS will take place in 2020.

### *2.6 Solid waste management – a case example*

The solid waste management activities in Seychelles started in 2016 and have included two tdCS, a six-month internship of a master's student, and a master's thesis. In all four projects, MEECC was the primary partner. Each topic was jointly selected by the partners, (i.e. ETH/TdLab, MEECC and the students).

Solid waste management in Seychelles is a pressing problem: The amount of waste to be dumped increases substantially every year. Landfilling is the current practice, and all sorts of waste (from organic to hazardous) are dumped at the same site. Non-sanitary landfills are leaching and may create serious environmental damage. Apart from PET bottles, aluminium cans and scrap metals, there is no recycling activity in place. Accordingly, sorting (at the source) is widely absent.

Waste is a very interesting topic from a sustainability point of view, as waste reflects the entire metabolism of a society. The topic is complex and requires a system-oriented and systematic approach. It involves technical, economic, social and environmental aspects and thus covers the entire spectrum of sustainability. These characteristics make solid waste an interesting topic for a case study.

Accordingly, a broad approach was pursued in the first tdCS in 2016. The content, procedure and results of this study are presented in the report of the case study and in a scientific article (cf. Lai et al., 2016; Meylan et al., 2018). The tdCS 2018, which is briefly presented below, was based on the results of the tdCS 2016. Representatives from ETH/TdLab and the Minister for Environment, Energy and Climate Change again jointly defined the global theme, which included sorting and post-sorting activities.

A total of 19 ETH students began their work with a literature review, which was complemented by input from lecturers to find topics to be worked out in smaller groups. After approximately three weeks, they split into smaller groups of 2–3 students based on a list of topics of interest that were created beforehand. After five weeks, the groups came up with draft research questions and rough research outlines, which were validated by three local experts from MEECC, the Landscape and Waste Management Agency (LWMA) and Indian Ocean Tuna (IOT) in a workshop in Zurich, about halfway through the semester. Based on their input, the students established seven topics, as depicted in Figure 1 and Table 2. For the rest of the semester, the students deepened their knowledge, specified methods, performed the first in-depth analyses and finalised their research plans. In parallel, ETH students started an exchange with their bachelor's

colleagues from UniSey in order to prepare field work and facilitate joint activities during the field phase in Seychelles.

***Figure 1**: Waste system framework and group breakdown*
( Source: Krütli et al., 2018a, p.14)

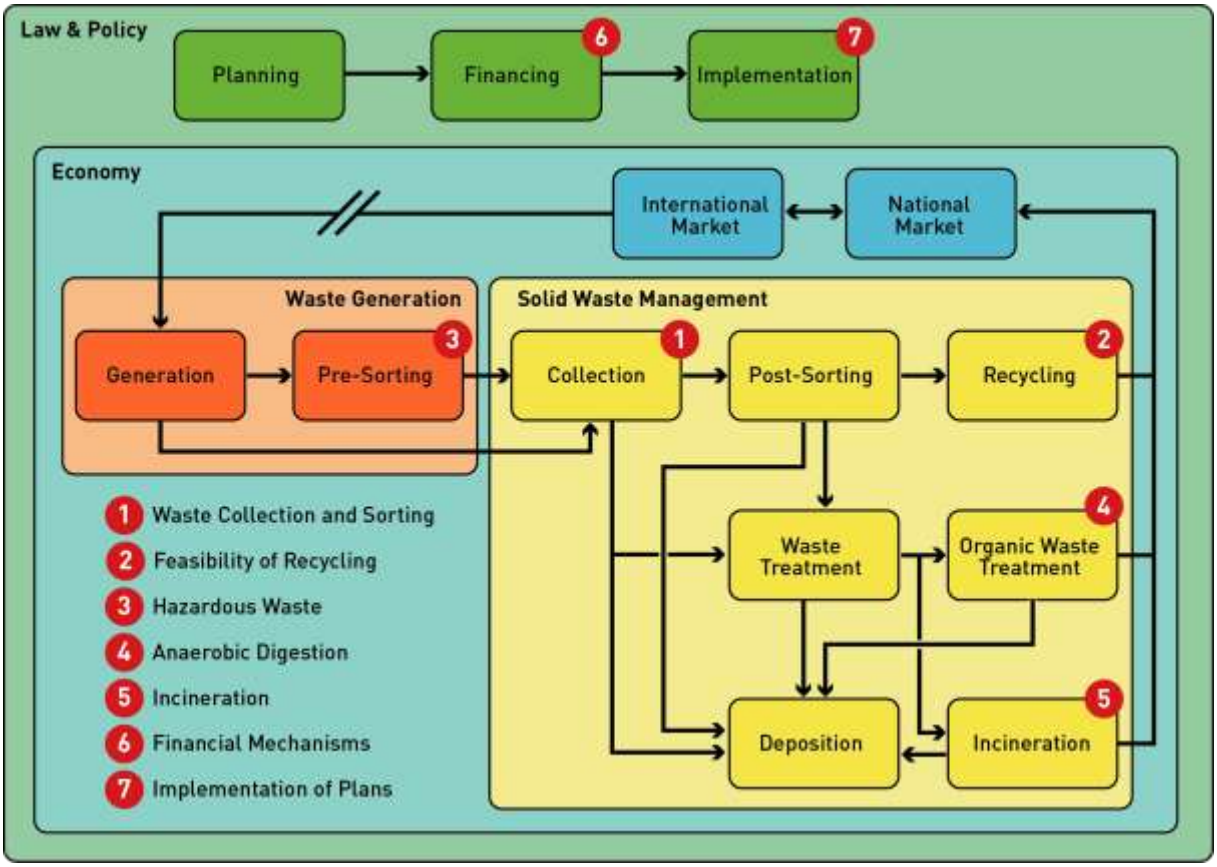

***Table 2**: Description of research groups and their methods*
(Source: Krütli et al., 2018a, p.15)

| Group | Description | Methods |
|---|---|---|
| (1) Waste Collection and Sorting: Consumers' Perspective | Household survey on the perception of the waste problem, particularly on waste collection and sorting preferences at the household level | Survey (questionnaire) involving a representative sample of 150 households from different regions and districts<br>Choice experiment to elicit collecting and sorting preferences<br>Face-to-face interviews with retailers and restaurant managers |
| (2) Feasibility of Recycling: An Appraisal Methodology | Development of a two-stage methodology to examine and prioritise potential recycling options Stages involve screening (exclusion process) and multicriteria-based assessment of options | Interviews with stakeholders and experts<br>Literature review<br>Multicriteria decision analysis, tested with some recycling products |
| (3) Hazardous Waste: Material Flows | Flow of hazardous waste based on the collection of data from various sources, such as weighbridge at Providence and Basel convention permits, import/export data | Data collection for material flows<br>Survey involving hazardous waste producers<br>Interviews with stakeholders and experts<br>Modelling of waste streams<br>Data interpretation and calculation |
| (4) Waste Treatment I: Anaerobic Digestion | Demonstration of the feasibility (technological and economic) of anaerobic degradation of organic material to reduce waste volume and generate energy | Landfill data analysis<br>Interviews with waste experts/stakeholders to construct scenario<br>Construction of organic waste stream scenarios<br>Plant design and cost analysis |
| (5) Waste Treatment II: Incineration | Demonstration of feasibility (technological, economic and social) of an incineration plant to reduce waste volume, generate electricity and process heat | Interviews with experts/stakeholders<br>Landfill data analysis<br>Calorific value/burning capacity calculation<br>Cost estimation<br>Survey on incineration acceptance |
| (6) Financial Mechanisms: Money Flows | Analysis of the current financial system of the waste management, comprising actors, money flows and economic instruments | Literature review<br>Interviews with local stakeholders<br>Modelling money flows |
| (7) Implementation of Plans: Barriers and the Way Out | Analysis of barriers to the implementation of plans, as well as ways to overcome these barriers | Literature review<br>Interviews with key stakeholders and experts<br>Workshop to validate identified barriers and solutions for better implementation of plans |

The field phase consisted of the joint activities of 19 ETH master's students and 14 UniSey bachelor's students and started with a kick-off event at UniSey, which was followed by a first meeting with the board of local experts and a site visit to the Anse Royale and Providence landfills. Data collection was the major activity of the fieldwork and took up about half of the time. In total, students interviewed and surveyed (most of them face-to-face) more than 350 people from the public and private sectors, the civil society in Seychelles, and academic institutions in Switzerland and elsewhere. The remaining time was used for data analysis and reporting. The field work culminated in a

public presentation of the preliminary results at the STC (Seychelles Trading Company) conference hall, Mahe.
Throughout the study, students worked independently and organised all their activities on their own. The teaching team of ETH coached the students and provided support on demand only, which is part of the didactic concept.

After returning to Switzerland, the ETH students were involved in revising the report drafts on a voluntary basis but were reimbursed as research assistants. The report drafts were validated by staff of MEECC, LWMA and the local advisory board of experts before they were finalised. The report was twice discussed with representatives from MEECC (including the Minister), LWMA, NGOs and other institutions in half-day events before it was handed over to the MEECC. The report is public and available online (https://tdlab.usys.ethz.ch/teaching/tdcs/former/cs2018.html).

The study concludes the following:

- There is momentum to establish a new waste management system: The political will to change seems to be present because MEECC has declared solid waste management a top priority. Initial approaches to waste sorting are available upon which further activities could be built. Alternative waste treatment options to landfilling, such as incineration, anaerobic digestion or Black Soldier fly larvae, which turn organic waste into proteins, are feasible.
- An integrated waste management approach is needed: Our study highlighted various facets of an integrated waste management system that should be implemented in stages. For example, the implementation of an incineration plant is associated with high investment and operational costs. However, incineration and other treatment options make sense only if a sophisticated sorting system is in place. This requires incentives and time, as citizens would not otherwise accept a new regime. Therefore, local capacities need to be built up to operate such facilities. New financing schemes need to be established in order to fund such activities.
- Leadership and further capacities are required: All the topics we investigated in our studies are linked to leadership and technical and institutional capacities that are needed to implement the proposed measures. Decision-makers concluded that the current system needs to be transformed from dumping to a system that acknowledges that waste is a resource that should be mined before disposal. This requires the political will to tackle this transformation and to enforce a new regime (see Krütli et al., 2018a).

Overall the tdCS 2018 involved approximately 40 students and academics and more than 350 locals. The students reached out to the broader public via newspapers and television. We estimate that in total the students and researchers worked more than 5,500 hours on this project.

The internship was based on a deficit identified in the tdCS 2018: e-waste. There is currently no e-waste separation in place, and data regarding the import, stocks and dumping of e-waste are widely missing. ETH/TdLab was approached by a Swiss student at the University of Wageningen, Netherlands, regarding an internship in Seychelles. ETH/TdLab, as the current coordinating unit of the SLLS, directed her to MEECC. The internship contract was finally made between the student and MEECC while Wageningen University supervised the internships academically. The goal of the six-month internship was to provide the ministry with an assessment of sources, categories and quantities of e-waste, which corresponds to a mass flow analysis (MFA). This is a major basic requirement for managing e-waste properly. Tasks of the intern also included stakeholder analysis and a methodological study on the e-waste categorisation. Data collection involved a total of more than 50 interviews and surveys with recyclers, retailers, businesses and administration. The outcome of the internship was a report on behalf of the MEECC.

The findings of the internship led to a master's thesis on e-waste recycling. In essence, the thesis needed to serve both the student's and the practice partner's needs and fulfil the academic standards of ETH Zurich. This thesis followed the goal of finding pathways to the implementation of an e-waste management in Seychelles. It provides a broad overview of the standards of international e-waste management and a description of contextualised e-waste management in Seychelles. The thesis involved more than 50 in-depth interviews with local and international stakeholders and experts and a consumer survey of 145 local participants. In addition to its sound theoretical foundation, the thesis provides concrete practical guidance and outlines contextualised activities for building an e-waste management in Seychelles.

***First policy changes to be observed***

Besides being a prolific and instructive experience for students from both universities, and the local partners and collaborators as feedback shows, the SLLS also has a measurable impact on policy and practice in Seychelles. Suggestions offered by students in the course of the tdCS as well as in the context of master's theses seemed likely to be followed-up and implemented (Krütli et al., 2018b). For example, students from the tdCS 2016 concluded that a position with clear tasks and allocated responsibilities is needed in the respective ministry in order to strengthen existing governance mechanisms (Dine et al., 2016). In the same year, government hired two experts who are exclusively dedicated to and responsible for the waste management (Krütli et al., 2018b). Furthermore, through the strong presence both in public, through media appearances and the participatory research approach, and in government bodies, through several workshops and advisory board events, the SLLS and especially the two tdCS have made a significant contribution to the nationwide discourse on waste management. This, in turn, may have indirectly (or directly) abetted to the ban of imports of plastic bags and styrofoam food boxes or the introduction of a levy system on imported glass. Furthermore, the LWMA is currently setting up a trial with individual household

waste bins that allow them to separate waste at source (Rapold, 2019) – a measure that has been recommended by the tdCS 2018. Finally, a new waste master plan is currently being elaborated. We expect it to take up elements that have been identified as urgent by our studies or that have been highlighted as being particularly promising and effective for sustainable waste management.

## 3. Lessons learnt from four years of activities, and the way forward

The SLLS is a learning space that makes it possible to bring together people from the public and private sectors and from civil society and academia to exchange information, jointly create new knowledge, share ideas and initiate new projects – all in the context of sustainability. To achieve these goals, four research-teaching formats have been established: the transdisciplinary case study, which is a problem-oriented and research-based teaching activity; master's and bachelor's theses, to be conducted in close collaboration with local partners; local courses to prepare UniSey students for the tdCS; and internships.

After four years of development, we can conclude that the SLLS is well underway but not yet in its mature state. Some elements are working very well while others need further attention. In the following, we will briefly discuss some issues and lessons learned.

### *3.1 Structure and organisation*

In general, the structure with the current four formats has proven successful. The tdCS, which takes place every two years, forms the core. With approximately 40 students, both from UniSey and ETH, and researchers and up to 400 participants per unit, it is a major event. The students and researchers of the two case studies worked a total of more than 10,000 hours, corresponding to roughly five man-years. Through its problem orientation, the tdCS has made a significant contribution to finding solutions to the waste problem in Seychelles. The master's theses (currently there are no bachelor's theses) form a second pillar. They often operate independently of the case study as stand-alone studies. However, this format would better realise its potential if the theses were related to the case study as follow-up activities to deepen the understanding of certain aspects. The case studies usually address a topic holistically. However, they are not a vessel for examining every aspect in depth. Master's and bachelor's degrees on the other hand are more appropriate for such an in-depth study. Internships are a form of practical implementation and therefore complement the above-mentioned formats. The aim of the local course (which has been conducted only once so far) was to prepare the students of UniSey for the case study one year ahead of the tdCS. In practice, this has not (yet) succeeded. One possibility for improvement would be to place a somewhat shorter event at the beginning of the second semester of study year 2. This would mean that the two cohorts of ETH and UniSey would start almost simultaneously in February. However,

this requires a time slot in the local curriculum. The three-week field work collaboration of the two cohorts is working well, but it would work even better if integration would happen at an earlier stage, as UniSey currently steps in without any preparation. The transdisciplinary approach and the diverse methods are complementary to the current education of undergraduates in Seychelles. This needs to be better communicated, as it is always a big problem to recruit enough local students. In the medium term, however, efforts are needed to better align the two curricula and to anchor such inter- and transdisciplinary formats in the local curriculum. From our point of view, this would make sense, as most graduates will integrate into the local labour market, and the skills that are acquired on this course should be in high demand in the local professional world, not least because sustainability requires non-linear, systemic thinking – an essential feature of the case study.

Organisational responsibility lies with ETH/TdLab. However, two MoUs with UniSey and MEECC secure close collaboration, provide essential organisational elements and ensure continuity. This structure gives the SLLS the necessary legitimation and supports the project institutionally. However, this organisational form is not resilient, as there is not yet a balanced share of responsibility, and if ETH were to step back the SLLS, it would be at risk of crashing. Ideally, the responsibility would lie with ETH/TdLab *and* UniSey in order to create continuity. In addition, the fact that ETH currently provides the means that are needed to run these activities does create an 'asymmetry of power', which might hinder cooperation. Another issue is related to the differences in the level of education between the two universities, and in general to cultural differences. This requires a lot of sensitivity, especially on the part of ETH Zurich. Accordingly, much attention is paid to competence building in terms of intercultural collaboration for our ETH students and staff. Finally, it is important to always involve a practice partner in the organisation as happened with MEECC. In terms of implementation, this is paramount because it increases the likelihood of materialising study results.

### *3.2 Teaching and research*

Most formats include teaching and research. These two aspects should not be separated, especially with the format of the tdCS, which represents research-based learning. With its four vehicles, the SLLS makes an essential contribution to education. Due to its research character and problem orientation, well-founded data are generated that are of direct benefit to the local society. In addition, the students have diverse knowledge and methodological skills, provide impulses and new ideas and, because they do not (yet) have a direct stake in the issue at hand, can also help to overcome any preconceived opinions and ideas that local actors might have. The basic mental attitude is an essential prerequisite for success or failure in innovation and transformation. The previously mentioned formats could be complemented by other more research-oriented formats. This would strengthen the SLLS, as sustainable development is based on solid scientific knowledge. The project collaboration with the Programme Coordination Unit (PCU) of the GoS (Government of Seychelles)-UNDP (United Nations Development

Programme)-GEF (Global Environmental Facility) environmental programme in Seychelles as an example, goes in this direction.

### *3.3 Collaboration and learning*

From a societal perspective, but also from the perspective of transdisciplinary research, collaboration with actors of practice is central. So far, more than 1,300 mostly local actors have been involved in our activities. This corresponds to about 1.5% of the local population. However, it is not only the quantity that counts. Some of the different stakeholders are being brought together in a new setting (e.g. experts from the administration with actors from private companies or with other administrations). This dialogue – often moderated by the students – helps to develop a common understanding of the problem and allows for social learning on topics such as waste. This dialogue also helps to better understand the position and behaviour of the other actors. Thus, an institutional representative of MEECC, for example, follows a different logic, by having to keep an eye on the optimal waste system, than an actor of a recycling enterprise who wants to maximise its benefit. This mutual understanding is an essential prerequisite for a coordinated and targeted implementation.

### *3.4 Implementation*

As shown above, transdisciplinarity also seeks to 'create change'. However, implementation has not yet been a focus for the universities. An important question arose after four years examining the subject of waste: What comes after we understand how the system works and what solutions are available to transform it? With our studies, we have been able to make a significant contribution to the necessary databases. However, the structures, the human and financial resources, have not changed significantly. It is therefore unclear whether the problem can be solved with these prerequisites. The question therefore arises as to whether the SLLS can and should play a role in implementation. The KFPE principle 10 explicitly proposes this: 'Many research projects in North–South partnerships belong to the category of result-oriented or implementation-oriented research. This means that the phase of disseminating scientific results must be followed by a phase of implementation and application' (KFPE, 2018, Principle 10). We fully agree; however, we also need to accept that research funding schemes very often do not include funding for implementation. One option to solve this is through co-funding by universities and e.g. institutional partners like MEECC (see also Ministerium für Wissenschaft, Forschung und Kunst in Baden Württemberg, 2013).

### *3.5 Long-term engagement*

Sustainability is not just a topic of the SLLS. The collaboration between ETH, which initiated this lab, and the local partners must likewise be oriented towards the paradigms of sustainability. The indispensability of longevity and continuity is particularly to be emphasized. Furthermore, cultural differences, different working styles and communication habits are a constant challenge. In addition, local institutions often lack human resources and expertise. To reduce the imbalance between different stakeholders,

much time, patience, continuous dialogue and a long breath are needed – along with individual commitment.

In summary, we can state here that the SLLS is a new and inspiring instrument that promotes learning between academia and society and can provide a significant impulse for sustainable development. The activities are problem-oriented but scientifically sound. A large number of people are involved. They are affected by the problem, have knowledge and expertise, can contribute to the solution or may be responsible for the implementation. This purposeful network of different actors is important in transforming a problem and allows learning at all levels. Most of the formats have proven their worth. However, the local university should become more involved. Furthermore, the different curricula should be better coordinated. Finally, the local partners should also think about making greater financial commitments, particularly to support the local university in its activities.

## 4. Conclusions

We have presented SLLS as a platform that brings together a huge number of people from all societal clusters and allows for dialogue and learning on all levels to better understand the benefits and challenges of sustainable development. The SLLS operates outside the standard public, private and societal networks and thought styles. Based on feedback, we have learned that this collaboration is appreciated by all involved parties and should continue. However, while it is working well in general, we still see room for improvements. Institutionally, for example, the partnership between ETH/TdLab and UniSey is not yet balanced. This issue should be given priority in the next phase, as UniSey may be key player at a later stage when the coordinating role of ETH decreases. More regular and better communication could help, but this would probably also require a commitment to resources on the part of UniSey (e.g. for a coordinator position). Furthermore, UniSey should find ways to integrate such an element in the current curriculum to meet the wishes of its students. To achieve its full potential, SLLS should also better engage with partners from the private sector and civil society, as learning about sustainable development is not an academic exercise alone; rather, all relevant actors must be part of this learning platform. Addressing a diversity of topics is fine, but the lab needs lighthouse projects (e.g. solid waste management) to demonstrate its functioning. In the near future, activities should be fuelled by concrete pilot projects to test and optimise sustainability projects. Waste sorting at source could become such a pilot. Activities would occur in close collaboration between MEECC, LWMA, S4S, a waste collection company and local volunteers with the academic support of UniSey and ETH. This should help to build the local capacity needed and provide the reservoir for creating a think tank for sustainable development at a later stage.

# References


Briguglio, L. (1995). Small island developing states and their economic vulnerabilities. *World development, 23* (9), pp1615-1632.

De Flander, K., Hahne, U., Kegler, H., Lang, D., Lucas, R., Schneidewind, U., . . . Wiek, A. (2014). Resilienz und Reallabore als Schlüsselkonzepte urbaner Transformationsforschung. *GAIA, 23* (3), pp284-286.

Dine, M., Dubois, I., Güttinger, E., Hämmerli, L., Rachel, A. and Pfister, O. (2016). Legal and institu tional framework. In A. Lai, J. Hensley, P. Krütli and M. Stauffacher (eds.), *Solid waste management in the Seychelles – USYS TdLab transdisciplinary case study 2016* (pp21-45). Zurich: USYS TdLab.

Edwards, P.J., Kollmann, J. and Fleischmann, K. (2002). Life history evolution in Lodoicea maldivica (Arecaceae). *Nordic Journal of Botany,* 22 (2), pp227-238. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1756-1051.2002.tb01371.x. doi:10.1111/j.1756-1051.2002.tb01371.x

Eriksson, M., Niitamo, V.P. and Kulkki, S. (2005). *State-of-the-art in Utilizing Living Labs Approach to User-centric ICT innovation – a European approach*. Centre of Distance Spanning Technology at Luleå University of Technology. Sweden; Nokia Oy, Centre for Knowledge and Innovation Research at Helsinki School of Economics, Finland.

Evans, J., Jones, R., Karvonen, A., Millard, L. and Wendler, J. (2015). Living labs and co-production: university campuses as platforms for sustainability science. *Current Opinion in Environmental Sustainability,* 16, pp1-6.

Fleischmann, K. (1997). Invasion of alien woody plants on the islands of Mahé and Silhouette, Seychelles. *Journal of Vegetation Science,* 8 (1), pp5-12. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.2307/3237236. doi:10.2307/3237236

Geibler, J.V., Erdmann, L., Liedtke, C., Rohn, H., Stabe, M., Berner, S., . . . Schnalzer, K. (2013). Living Labs für nachhaltige Entwicklung: Potenziale einer Forschungsinfrastruktur zur Nutzerintegration in der Entwicklung von Produkten und Dienstleistungen.

Gibson, R.B. (2005). *Sustainability assessment: criteria and processes.* New York: Earthscan.

Government of Seychelles. (2011). *Fourth National Report to the United Nations Convention on Biological Diver sity*. Retrieved from https://www.cbd.int/doc/world/sc/sc-nr-04-en.pdf

Hirsch Hadorn, G., Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Joye, D., Pohl, C., . . . Zemp, E. (eds.). (2008). *Handbook of Transdisciplinary Research*: Springer.

Jahn, T., Bergmann, M. and Keil, F. (2012). Transdisciplinarity: Between mainstreaming and marginali zation. *Ecological Economics,* 79, pp1-10.

Jahn, T. and Keil, F. (2016). Reallabore im Kontext transdisziplinärer Forschung. *GAIA-Ecological Perspec tives for Science and Society,* 25(4), pp247-252.

Jantsch, E. (1972). Inter- and transdisciplinary university: A systems approach to education and innova tion. *Higher Education,* 1(1), pp7-37. doi:10.1007/bf01956879

KFPE. (2018). *A guide for transboundary research partnerships - 11 principles* (3rd ed.). Retrieved from https://naturalsciences.ch/uuid/564b67b9-c39d-5184-9a94-e0b129244761?r=20190205110021_1549338276_8ef687bc-7b14-5a4f-ad9e-bf494cddc1d7

Klein, J.T. (2013). The Transdisciplinary Moment(um). *Integral Review,* 9 (2), pp189-199.

Klein, J.T., Grossenbacher-Mansuy, W., Häberli, R., Bill, A., Scholz, R. W. and Welti, M. (eds.). (2001). *Transdsiciplinarity: Joint problem solving among science, technology, and society. An effective way for managing com plexity*. Basel: Springer.

Kockelmans, J. (1979). Why interdisciplinarity? In J. J. Kockelmans (ed.), *Interdisciplinarity and higher edu cation*, pp123-160. University Park: Pennsylvania State University Press.

Krütli, P., Nef, D., Zumwald, M., Haupt, M., Harlay, J. and Stauffacher, M. (eds.). (2018a). *Waste Management in the Seychelles – Pathways for Systemic Change*. USYS TdLab Transdisciplinary Case Study 2018. ETH Zurich: USYS TdLab.

Krütli, P., Pohl, C. and Stauffacher, M. (2018b). Sustainability Learning Labs in Small Island Developing States: A Case Study of the Seychelles. *GAIA - Ecological Perspectives for Science and Society,* 27 (6), pp46-51. Kueffer, C. (2010). Reduced risk for positive soil-feedback on seedling regeneration by invasive trees on a very nutrient-poor soil in Seychelles. *Biological Invasions,* 12 (1), pp97-102. Retrieved from https://doi.org/10.1007/s10530-009-9433-4. doi:10.1007/s10530-009-9433-4

Lai, A., Hensley, J., Krütli, P. and Stauffacher, M. (eds.). (2016). *Solid Waste Management in the Seychelles*. USYS TdLab Transdisciplinary Case Study 2016. ETH Zurich: USYS TdLab.

Liedtke, C., Jolanta Welfens, M., Rohn, H. and Nordmann, J. (2012). LIVING LAB: user-driven innova tion for sustainability. *International journal of sustainability in higher education,* 13 (2), pp106-118.

McCormick, K. and Kiss, B. (2015). Learning through renovations for urban sustainability: the case of the Malmö Innovation Platform. *Current Opinion in Environmental Sustainability,* 16 (Supplement C), pp44-50. Retrieved from http://www.sciencedirect.com/science/article/pii/S1877343515000639. doi:https://doi.org/10.1016/j.cosust.2015.06.011

Meylan, G., Lai, A., Hensley, J., Stauffacher, M. and Krütli, P. (2018). Solid waste management of small island developing states—the case of the Seychelles: a systemic and collaborative study of Swiss and Sey chellois students to support policy. *Environmental Science and Pollution Research,* 25 (36), pp35791-35804. Retrieved from https://doi.org/10.1007/s11356-018-2139-3. doi:10.1007/s11356-018-2139-3

Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg (2013). Wissenschaft für Nachhaltigkeit Herausforderung und Chance für das baden-württembergische Wissenschaftssystem. Retrieved from https://www.baden-wuerttem-berg.de/fileadmin/redaktion/dateien/PDF/Broschüre_Wissenschaft_für_Nachhaltigkeit.pdf

Pohl, C. (2011). What is progress in transdisciplinary research? *Futures,* 43 (6), 618-626. Retrieved from http://www.sciencedirect.com/science/article/pii/S0016328711000644. doi:https://doi.org/10.1016/j.futures.2011.03.001

Pohl, C. and Hirsch Hadorn, G. (2007). *Principles for designing transdisciplinary research*. Munich: Oekom.

Pohl, C., Krütli, P. and Stauffacher, M. (2017). Ten Reflective Steps for Rendering Research Societally

Relevant. *GAIA-Ecological Perspectives for Science and Society,* 26 (1), pp43-51.

Rapold, N.S. (2019). *A Pathway Towards the Implementation of an Electronic Waste Management System in Sey chelles - Status Quo Analysis and Assessment of Future Strategies.* (Master's Thesis), ETH, Zurich.

Rittel, H.W.J. and Webber, M.M. (1973). Dilemmas in a general theory of planning. *Policy Sciences,* 4 (2), pp155-169. Retrieved from https://doi.org/10.1007/BF01405730. doi:10.1007/bf01405730

Rosenberg Daneri, D., Trencher, G. and Petersen, J. (2015). Students as change agents in a town-wide sustainability transformation: the Oberlin Project at Oberlin College. *Current Opinion in Environmental Sus tainability,* 16 (Supplement C), pp14-21. Retrieved from http://www.sciencedirect.com/science/article/pii/S187734351500069X. doi:https://doi.org/10.1016/j.cosust.2015.07.005

Schäpke, N., Singer-Brodowski, M., Stelzer, F., Bergmann, M. and Lang, D. J. (2015). Creating space for change: real-world laboratories for sustainability transformations: the case of Baden-Wurttemberg. *GAIA-Ecological Perspectives for Science and Society,* 26 (4), pp281-284.

Trencher, G., Rosenberg Daneri, D., McCormick, K., Terada, T., Petersen, J., Yarime, M. and Kiss, B. (2016). The Role of Students in the Co-creation of Transformational Knowledge and Sustainability Ex periments: Experiences from Sweden, Japan and the USA. In W. Leal Filho and L. Brandli (eds.), *Engag ing Stakeholders in Education for Sustainable Development at University Level* , pp191-215. Cham: Springer Inter national Publishing.

United Nations. (2014). *Trends in sustainable development: Small Island Developing States (SIDS)*. Retrieved from New York: https://sustainabledevelopment.un.org/content/documents/1954TR2014.pdf

United Nations WCED. (1987). *Report of the World Commission on Environment and Development (WCED): "Our common future."*. Retrieved from https://sustainabledevelopment.un.org/milestones/wced

Wagner, F. and Grunwald, A. (2015). Reallabore als Forschungs-und Transformationsinstrument Die Quadratur des hermeneutischen Zirkels. *GAIA-Ecological Perspectives for Science and Society,* 24 (1), pp26-31.

---

*The TdLab is located within the Department of Environmental Systems Science of ETH Zurich. It conceptualizes and tests educational and research approaches to tackle complexities of sustainable development. The TdLab enables students to experience and tackle real-world problems in the context of sustainable development through collaborative and reflective teaching. In doing so, students integrate knowledge and values from different scientific perspectives, as well as from other societal actors. The TdLab is co-directed by Dr. Pius Krütli, Dr. Prof. Michael Stauffacher, and Dr. Christian Pohl. Pius Krütli and Michael Staffacher are the responsible teachers of the transdisciplinary case study (tdCS) in Seychelles. Pius Krütli also leads the Sustainability Learning Lab in Seychelles (SLLS). Danny Nef is a PhD student at TdLab and tutor for the tdCS in Seychelles.*