Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Water catchment areas in the Seychelles: Vegetation quality and human impact analysis and evaluation

Master thesis

Stéphanie Massy & Mélanie Schmutz

Supervisors: Dr. Pius Krütli, Dr. Karl Fleischmann

Department of Environmental Systems Sciences
April 2017

Table of content

This document constitutes a revised version of the original master thesis. This revised version is included in the report: “Assessment of the ecosystem service and vegetation rehabilitation of the Val d’Endor watershed” which will be published in 2017 by the GOS / UNDP / GEF Programme Coordination Unit: Ecosystem Based Adaptation to Climate Change in Seychelles in collaboration with UniSey and ETH Zürich.

Summary

Changes in the hydrological cycle with climate change are expected to have significant impacts in the Seychelles. Predictions of these changes are uncertain. It is however expected that the risk of extreme events such as flooding and longer periods of drought will increase. Furthermore, pressure on watershed areas by human activities such as housing, land use practises, and infrastructure facilities is likely to increase. These can affect water catchment areas ecosystem services such as freshwater provision and water retention. In this context, the Ecosystem Based Adaptation (EBA) project aims to enhance freshwater security through prevention from flooding by restoring, for example, native forests in water catchment areas. This thesis is embedded in the EBA project. Its aims is (i) to characterize the Val d'Endor watershed in terms of the ecosystem services, (ii) to identify trade-offs between competing land use practises and stakeholder interests, and (iii) to provide an information baseline which may be used in the creation of upcoming water catchment policies.

We follow a systemic approach integrating bio-physical elements, infrastructure, land use practises, decision making and policy structure. More concretely, (1) we investigated the vegetation quality and (2) we characterized and assessed human activities and impacts (potential polluters, infrastructures, agriculture, water management, etc.) in the Val d'Endor watershed area. For the vegetation analysis, we investigated Vegetation Quality Indices (PtVs and VQI), the prominence of trees, patterns of invasion, species diversity, species density and dominance, and ground cover estimation in ten trail transects and in ten permanent sampling plots in the Val d'Endor watershed. Particular attention was given to native versus exotic species as they are good indicators of the quality and vitality of the forest system. In terms of human activities, we analysed the watershed area following a qualitative system analysis approach. Based on a desk study, informal talks and semi-structured interviews, we proposed a set of 16 descriptors by which the structure and dynamic of the system of the Val d'Endor watershed can be characterised. A reduced set of 11 descriptors fed into the construction of scenarios which describe how the system might evolve in the next 30 years. In addition to the current state, these scenarios were evaluated by seven stakeholder groups first (a) holistically in terms of desirability and probability and secondly (b) by using criteria to identify areas of agreement and disagreement among the stakeholders.

Results of the vegetation analysis show that native and exotic plant species follow different distribution patterns throughout the watershed. We have identified three sites with medium and high quality vegetation while all the other seven sites present low quality vegetation (absence or very low abundance of endemics, very high abundance of exotics, medium regeneration of natives, and low diversity of natives). These three sites would require special attention for rehabilitation. Forest rehabilitation may be carried out on selected Val d'Endor sites by taking measures to assist natural regeneration (e.g. through the control of invasive woody tree species), and by taking measures to accelerate natural recovery by direct seeding or by planting seedlings (with native woody species). Regarding the qualitative system analysis and scenario evaluation, major environmental concerns were revealed. Rivers pollution and water availability seem to be major issues in the watershed. Our perception study reveals areas of dissensus and consensus among stakeholders regarding future management of the watershed. Overall, people seem to be more satisfied by sustainable scenarios (i.e., increasing legal context and law enforcement on protection of watershed) but they have different desires (driven by personal interest) on the development of the watershed. However, the scenarios which are desired by most participants are regarded to be the least probable.

This thesis provides an evidence-based baseline to instigate improvements of the ecosystem services of the watershed. It allows formulating recommendation for the rehabilitation of the Val d'Endor watershed, and allows setting the basis for post-rehabilitation monitoring. It also provides the background necessary for ecosystem-based management and for the conception of local and national policy on water catchment protection.

Acknowledgement

We hereby want to thank our two supervisors Dr. Pius Krütli (TdLab) and Dr. Karl Fleischmann (UniSey) without whom this thesis would not have been possible. They gave us great guidance, advices and constructive feedback. We would like to thank Dr. Karl Fleischmann for familiarization with Seychelles Forests and Flora and Terrence Vel for field assistance. A special thank goes to the EBA project team: James Millet and Betty Seraphine for overall support and help, Johan Mendez for hydrological information, Eldrick Adelaide for transport and Betty Mondon for help with the community. In addition, we want to thank Elyn Albert who provided us outstanding GIS maps. Furthermore, special thanks to people from the Seychelles Agricultural Agency, from the Ministry of Land use and Housing, from the Ministry of Environment, Energy and Climate Change, from Public Utility Corporation, from Seychelles National Meteorological Services, from Landscape and Waste Management Agency, from Public Health Authority, students and professors of the University of Seychelles and farmers and residents of the Val d'Endor, for providing data and/or participating to the interviews and survey. We would also like to thank Prof. Dr. Olaf Tietje for familiarization with the software SystemQ used in this thesis. This thesis would not have been possible without financial support, thus we would like to thank the ETHz and the Tdlab for flight and accommodation support. Finally, we thank our family for their financial and moral support throughout this thesis and Bertrand Massy for the final proofreading.

List of abbreviations

ANOVA	Analyses of Variance
DA	District Administration
DBH	Diameter at Breast Height
EBA	Ecosystem Based Adaptation
GEF	Global Environment Facility
LWMA	Landscape and Waste Management Agency
MEECC	Ministry of Environment, Energy and Climate Change
MET	Seychelles Meteorological Services
MFA	Ministry of Fisheries and Agriculture
MFAT	Ministry of Foreign Affairs and Transport
MH	Ministry of Health
MLUH	Ministry of Land Use and Housing
PCU	Programme Coordination Unit
PHA	Public Health Authority
PMC	Property Management Cooperation
PP	Permanent Plot
PtV	Protection Value
PUC	Public Utilities Corporation
PV	Prominence Value
H'	Shannon-Weaver Diversity Index
SAA	Seychelles Agricultural Agency
SSDS	Seychelles Sustainable Development Strategy
SLTA	Seychelles Land Transport Agency
SNCCS	Seychelles National Climate Change Strategy
UNDP	United Nations Development Program
UniSey	University of Seychelles
VQI	Vegetation Quality Index

A. Introduction

Concerns have been raised about the impact of climate change in the Seychelles. Like many other small islands, Seychelles is already facing different problems such as shift in rainfall patterns (Parry, 2007). Indeed, the dry southeast monsoon season is expected to become drier and the period between rainfall events during this season is expected becoming longer (EBA report, 2013). There is strong evidence that under most climate change scenarios, water resources in small islands are likely to be seriously compromised due to expected longer periods of droughts (Parry, 2007). As a consequence, the Seychelles is expected to face freshwater shortage due to limited water storage capacities. On the other hand, based on Seng and Guillande (2008) study results, it is also expected that the rainy season has a higher chance to become wetter, meaning heavier and more intensive rainfall which might lead to more flooding. Changes in intensity of rainfall will increase runoff and risk of flooding which depend on the water catchment's physical and biological characteristics (INC, 2000). In other words, freshwater supply and retention of water by catchment areas are major issues that the Seychelles will be facing in the future.

This is the reason projects such as the Ecosystem Based Adaptation project have been initiated (EBA report, 2013). This thesis is embedded in component 1 of this project (3 components in total). Its goal is to reduce the vulnerability of the Seychelles through preventing water scarcity and flooding. The project aims to restore ecosystem functionality, to enhance ecosystem resilience and to sustain watershed and coastal processes in order to secure critical water provisioning and flood attenuation ecosystem services from watersheds and coastal areas (EBA report, 2013). More particularly, component 1 aims to enhance freshwater security by restoring, among others, native forests in water catchment areas in order to adapt to climate change.

A specific attention on ecosystem services of water catchment areas is required. A watershed as an ecosystem plays a very important role in providing goods and services that contributes to human wellbeing. Ecosystem services are defined as the benefits people obtain from ecosystems (MEA, 2005), which ultimately contribute to their own wellbeing. Well-being can be seen as maintenance of good health, recreation, aesthetic enjoyment, etc. (Boyd and Banzhaf, 2007). The Millennium Ecosystem Assessment (2005) classifies these ecosystem services in four different categories:

- **Provisioning services** such as food and fresh water;
- **Regulating services** such as water regulation and climate regulation;
- **Cultural services** such as recreation and ecotourism;
- **Supporting services** such as nutrient and water cycling.

However, Wallace (2007) argues that this classification is mixing processes and services within the same level and thus is not effective for decision making. For example, water cycling and water regulation are rather processes than services. In other words, they are means to deliver an end product such as potable water. Furthermore, if one has to value ecosystem services, the classification above could lead to a double counting of services (Boyd and Banzhaf, 2007). Wallace (2007) thus proposes another categorization where ecosystem services, experienced directly by individuals, are systematically related to specific human values. The ecological processes are not anymore accounted as services but as intermediate processes that are necessary to deliver end product services (Wallace, 2007). Other classifications can be found in the literature e.g., De Groot, Wilson et al. (2002). The first step here is to translate ecosystem structure and processes into a fewer number of ecosystem functions. These functions are the ones providing services, which are then valued by humans (De Groot, Wilson et al., 2002).

In this thesis, we consider ecosystem services as end product, because we think that it is the best solution to analyze and value them in a systematic way. We acknowledge, however, that intermediate products or processes are as well important, but will consider them as such. In catchment areas, water supply such as potable water and water for agriculture and recreation can be seen as end product services. However, water retention, carbon sequestration and air pollutant removal can be seen as processes. The benefits humans can have from these areas are, for example, flood damage mitigation and availability of drinking water. Forests in the former are the service (end product), while for the latter, forests are intermediate components which influence the availability of water (Boyd and Banzhaf, 2007).

The estimation of the societal value of ecosystem services is essential in ecosystem-based management for local and national policy conception as well as for decision-making. It is important to understand the social and individual "relations" people have with both fresh and waste-water related services as users (e.g., residents, farmers, tourists) and to identify their respective activities that have impacts on the quality of catchment areas. It is essential to understand how this can be used to address current and future water challenges at the catchment level in the Seychelles.

Another very important aspect of reducing the risks of water scarcity that need to be investigated is the role of the forest in the catchment as vegetation and ground conditions play an important role in the hydrological cycle (Brauman et al., 2007; Waring and Running, 2010). Indeed, vegetation cover is of great importance for watersheds, because it lowers the excessive overland water flow, but also reduces soil erosion (Gregersen al., 2007) and in period of dry season, it helps to increase the stream flow (Brooks al., 1990). The hydrological cycle is not only influenced by the vegetation's density but also by the types (natives vs. exotics) of trees found in the catchment even though very little is known on this matter (see below). Indeed, exotic species are important in this context, because they can have lots of different effects on the ecosystem such as alterations of biogeochemical cycles, alteration of geomorphological cycles and a change in hydrological cycles (Blossey, 1999). It is argued that invasive alien species, particularly tree species, often require much more water compared to native vegetation (Calder and Dye, 2001). On the other hand, Yamamoto and Anderson (1967) found out that the hydrological properties of the soil are not related to the type of tree, i.e. native or exotic. Furthermore, the hydrological function of the soil is not necessarily impaired because of replacement of native forest with exotic forest (Ataroff and Rada, 2000). But in general, little is known about how shifts in vegetation impact the hydrological processes (Troch et al., 2009).

From the different perspectives presented above, i.e. the role of forest and the role of human in/on water catchment, one can see that there is still lack of knowledge. This thesis is embedded in an overall assessment of the ecosystem service of water catchment which consist of (I) studies on the vegetation quality, (II) testing the water quality of selected watersheds on Mahé, (III) monitoring the water flow rate (i.e. water availability) in these areas, (IV) assessing the forest light climate as the main driver of plant invasions and (V) providing an insight about the canopy structure by using drones. In order to assess the major downsides of these services it was decided to (VI) characterize human activities (potential polluters, infrastructures, agriculture, water management, etc.) and evaluating human perceptions on ecosystem services of a watershed. This project follows a systematic approach and bears a transdisciplinary character.

The first component of the EBA project starts with the Val d'Endor watershed, because no particular studies about this catchment on ecosystem services have been done so far. Thus, we have defined the following research question: *"How can Val d'Endor water catchment (a) be characterized in terms of* *ecosystem services focusing on water provision and retention, and (b) how can these services be evaluated?"*

Within this context, this thesis seeks to address two aspects: forest quality and human analysis. This work contributes to the VI elements mentioned above in the attempt to provide a more holistic assessment of the eco-service of the Val d'Andor watershed. Furthermore, the investigation of these aspects will serve as a baseline for (1) the post-rehabilitation monitoring and (2) for necessary intervention/mitigation, in the attempt to improve the ecosystem services of water catchments in the future. As a result, the goals of this thesis are:

- To characterize and evaluate the Val d'Endor watershed in terms of the ecosystem services and identify trade-offs between competing land use practices and stakeholder interests.
- To include local communities, governmental agencies, non-governmental agencies and the private sector into the analysis and evaluation of ecosystem services of the watershed, because it will allow to give the full picture of water catchment services and its potential limitations.
- To present useful data for the vegetation rehabilitation of the Val d'Endor water catchment by including an analysis on perception and evaluation of ecosystem services by different stakeholder groups. This will provide a baseline for the management of the watershed (i.e. which areas need absolute protection, which areas can be used for other purposes (housing, agriculture), what is the impact of exotic species on specific area, etc.).

To answer the general research question and achieve these specific goals, we will in the next chapters characterize the composition and structure of the vegetation (only tree species; no herbs and pteridophyta included in the study) in order to find out (1) the biodiversity of Val d'Endor watershed, (2) the density (number of trees/ha) and dominance (DBH-cross sectional area m^2 /ha) of trees, (3) the relative abundance of woody seedlings, (4) the prominence of trees (adults and saplings) and (5) the key exotic species and the state of invasion. In addition, we will also analyse the current situation in terms of (a) water management (i.e. provision, treatment, pollution), (b) housing, (c) infrastructure, and (d) land use like agriculture. In a second step, we will evaluate the water catchment area (i) by using Vegetation Quality Indices (for the vegetation), and (ii) do a scenario evaluation by different stakeholder groups. Considering and including stakeholders is important for assessing and enhancing political and societal feasibility, especially when it comes to implement changes in a problematical situation (Checkland and Scholes, 1999; Bryson, 2004).

The next chapters of this thesis are structured as follow:

Chapter B describes the study area (Val d'Endor watershed).

Chapter C describes the vegetation analysis and assessment with methods, results, discussion and limitation.

Chapter D presents the human analysis and human perception on ecosystem services which includes methods, results, discussion and limitation.

Chapter E presents the general conclusion of the whole thesis and aim to answer our research question.

The references can be found in chapter F (literature, list of figures and tables) and the appendixes are found in chapter G. The latter includes the questionnaire, figures, tables and the declaration of originality.

B. Study area

Val d'Endor watershed (Figure C1) is located on Mahe Island and more specifically in the Baie Lazare district. The watershed is considered as an important agriculture area on Mahe Island. The main river of the water catchment is the Baie Lazare River, which comprises some 23 tributaries from spring sources. The river is used for water supply (domestic use and irrigation). The catchment has a total area of 3.6 km^2. There is one main road going through the watershed from west to east. The watershed is delimited by natural boundaries, i.e. ridge lines or watershed lines which have altitudes between 221 and 378m. There are three main hills around the watershed: Maravi at 221m on the south east, Mont Parnel at 378m on the south west and Le Desert at 330m in the north west. Based on the Ministry of Land Use and Housing land use plan, approximately 60% of the watershed is composed of forest, while 30% goes to farming activities and the rest is residential area.

C. Part I – Vegetation quality

C1 Methods

This section will go over the methodology used (1) to analyse the vegetation, and (2) to assess the quality of the vegetation in Val d'Endor watershed.

C1.1 Vegetation analysis

For the vegetation analysis we used the Prominence Value (PV), the Shannon-Weaver Diversity Index (H'), the abundance of exotic trees, the tree density, the tree dominance and the ground cover. In order to make these calculations possible, we used 10 intensive monitoring sites made up by 10 permanent sampling plots and 10 forest transects in the catchment (Figure C1). The transects were chosen according to certain criteria: (1) the site shows a natural rejuvenation, (2) it is not invaded by *Merremia p.* and *Clidemia h.,* (3) the access to the transect is not too complicated, (4) and it has the potential to be rehabilitated. The intensive monitoring sites were selected along riverbeds and the permanent plots were always situated on the transects or very close to them. They were chosen in order to well represent the diversity of the different sites. The transects are marked as followed: 5 beacons are placed at 50m distance from each other. Those beacons were marked permanently with concrete and properly labelled from 1 to 5. All beacons GPS points of the 10 transects can be found in APPENDIX G2 (Table G1).

C1.1.1 Transect lines

In order to calculate the Prominence Value, the Shannon-Weaver Diversity Index, the abundance of exotic trees and the Vegetation Quality Indices (PtVs and VQI) (for the latter, see section C1.2) we followed Fleischmann's methodology (e.g. Fleischmann, 1997; Fleischmann et al., 2005; Fleischmann and Gamatis, 2016). The transect lines were also used to estimate the likely increase or decrease of exotic species. In order to do that, we first collected the data along the 10 different transects (*Dan Merl, Dan Karolin west, Dan Tombalo low, Dan Pinpin up, Dan Pinpin low, Dan Karolin east, Dan Teso, Dan Marizan north, Dan Marizan south, Dan Tombalo up*). For each transect, we started at beacon 1 and walked in a straight line to beacon 2 and so on. The recordings were made every 2.20 meters along the transect line and the closest tree as well as the closest sapling at right angles to each sampling point were noted. The trees are defined according to the following criteria: (1) broadleaf trees have a diameter at breast height (DBH) > 3cm, (2) adult palms have a true stem. Saplings are defined in the following way: (1) broadleaf tree saplings have a DBH < 3cm and their height is >50 cm, and (2) the leaf length of palm saplings is > 1m). A hundred enumerations were done for each transect. It means that we walked 220 m in total, thus for each transect we surpassed the first or last beacon by 20 m. In order to make this survey comparable with earlier publications by Fleischmann et al. the 220 m transect length unit was chosen as for being consistent with the average pace-length (i.e. 2.20 m for three steps) when Fleischmann was only using a step counter in his earlier work in areas with extremely difficult topography. On the map (Figure C1), polygons of different colors represent forest areas which are considered to be homogenous in terms of forest structure and species composition.

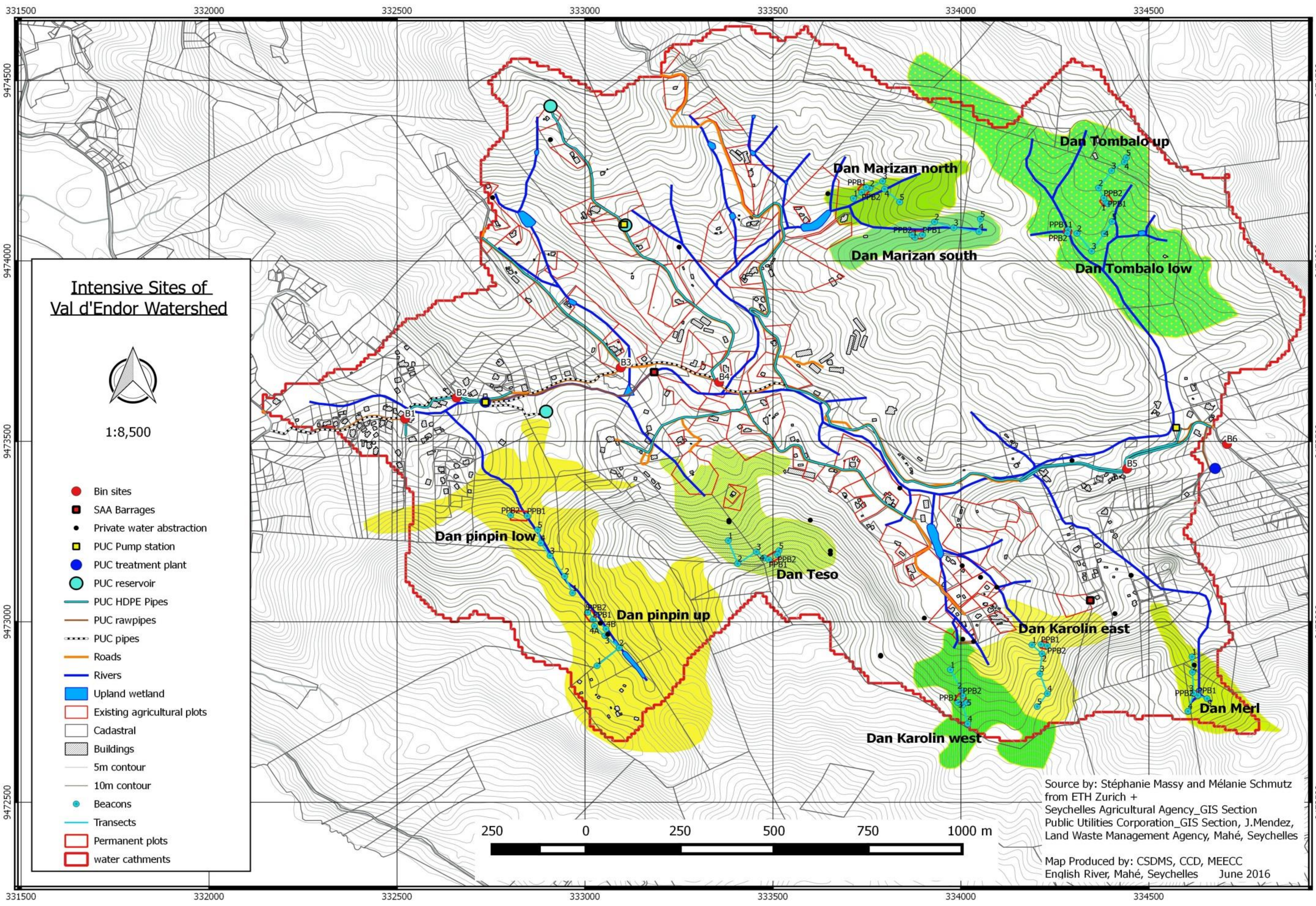


Figure C1: Intensive sites of Val d'Endor watershed (10 transects and 10 permanent plots).

C1.1.2 Prominence Value

To calculate the PV of the tree species found in the Val d'Endor water catchment, we first calculated the abundance in the 10 transects, then the frequency of occurrence of each species in the whole watershed was derived. The abundance is classified in 7 classes (Table C1). The scale is weighted towards low numbers, in order to not downweight the significance of rare species in the different sites.

Table C1: Abundance classes for 100 subsequent individuals in each transect.

ABUNDANCE							
Class	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Number of individuals	1	2 – 4	5 – 8	9 - 16	17 – 32	33 – 64	> 64

The frequency of occurrence (f_{ij}) of species i is calculated as follow:

$$f_{ij} = \frac{n_{ij}}{n_j} \times 100$$

where n_{ij} is the number of transect j having species i, and n_j the total number of transects.

It is then possible to calculate the Prominence Value (PV_{ij}) for a species i in transect j as follow:

$$PV_{ij} = \frac{f_{ij}}{\sum_i f_{ij}} \times 100 + \frac{\sum_k a_{ijk}}{\sum_i \sum_k a_{ijk}}$$

where a_{ijk} represents the abundance class value of species i in sampling unit k of transect j.

C1.1.3 Abundance of exotic trees

The abundance of adult exotic tree species and the abundance of exotic tree saplings was recorded for each transect (see APPENDIX, Table G4 to G13). We represented the likely forest succession by plotting the abundance of adults versus saplings in graphs (one for each site). The relations between the rel. abundance of adults vs. the rel. abundance of saplings allow an estimation of the future forest succession, i.e. species above the cut-off line are likely to increase in abundance. Plus, distribution maps of the relative abundance of adult tree of the 6 most prominent exotic species were created. For the latter, the abundance of the species was grouped as follows: rel. abundance 1-10 = low grade of invasion, 11-30 = medium grade of invasion, >30 high grade of invasion.

C1.1.4 Shannon-Weaver Diversity Index

The Shannon-Weaver Diversity Index (H') was used for the ten different transects and for adults and saplings:

$$H' = -\sum_{i=1}^{n} pi\ ln(pi)$$

where n is the total number of species in the transect, and p_i proportion of n made up of the ith species.

C1.1.5 Permanent plots

Permanent plots are small area within or next to the transect lines, that well represent the transects in terms of forest structure and density. The permanent plots (PPs) were used to calculate the (1) tree density, (2*)* tree dominance, and (3) to estimate the ground cover. The permanent plots can be seen on Figure C2 and are named as PPB1 and PPB2 (permanent plot beacon 1 and permanent plot beacon 2 respectively). They were also marked permanently in the field. All PPs have an area of 10*25m. The PPs were subdivided into 5 rectangles of an area of 5*10m (labelled from 1 to 5), each of them is again subdivided into 4 rectangles of 2.5*5m (i.e. R1, L1, R11 and L11) (Figure C2). From L1 to L5 and R1 to R5 (10 rectangles) different vegetation features were recorded: (1) the occurrence of all adult wooden species, (2) the height of the trees, (3) the DBH of adult trees, (4) the presence of all seedlings and saplings, (6) the height of saplings, and (7) the nature of the bare ground cover. From L11 to L55 and R11 to R55 (10 rectangles), the vegetation survey comprised: (1) enumerating all adult tree species, (2) measuring the DBH of adult trees, (3) estimating the trees' height, (4) enumerating all woody saplings, and (6) measuring the height of the saplings. Pictures of each of 5*10m rectangle were taken in the 10 PPs for future photo-monitoring of the respective sites (pictures showed on request). Two beacons in a concrete foundation define permanently the location of each PP. The exact GPS location of all beacons can be found in APPENDIX G2 (Table G2).

C1.1.6 Tree density

First the Diameter at Breast Height (DBH) data were grouped into four diameter size classes, for instance: class I = 3cm – 10cm, class II = 11cm – 30cm, class III = 31cm – 60cm, and class IV > 60 cm. The tree density was then determined for each size class per site (per permanent plot), for each size class of the total watershed and finally for each size class per species. The tree density is calculated in terms of individuals/hectare.

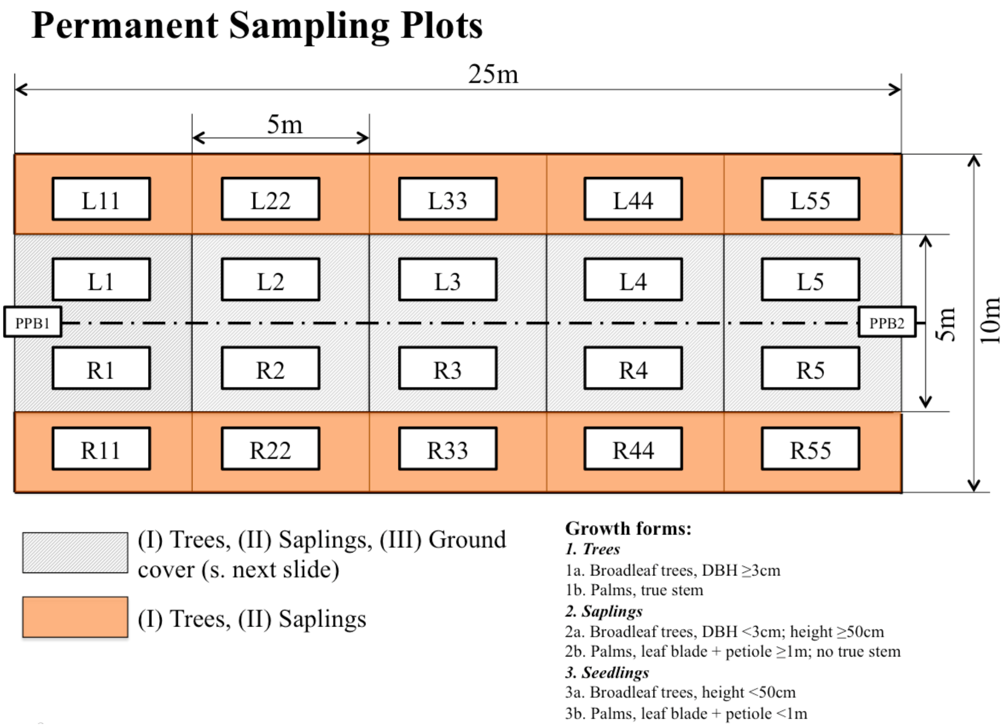


Figure C2: Area and structure of a permanent sampling plot.

C1.1.7 Tree dominance

In order to calculate the tree dominance, the data were transformed into basal area (m^2/ha):

$$BA = \pi \times \left(\frac{DBH}{2}\right)^2$$

Following the same data transformation as for the tree density, the data for the tree dominance were assigned to the same four size-classes shown in C1.1.6. The tree dominance was then calculated (1) for each permanent plot, (2) for the total watershed and (3) for each species.

C1.1.8 Ground cover

Ground cover is the area of the PP occupied by the above-ground parts of a plant when viewed from above. The canopies of the plants inside the sub-plot will often overlap each other, so the total percentage cover of plants in a single sub-plot will frequently add up to more than 100%. Ground cover refers to enumeration of (1) tree seedlings < 50cm (for palms, length of leaf blade + stalk <1m), (2) known and unknown herbaceous plants, and (3) the analysis of uncovered area such as bare ground and rocks. In each sub-plot, from L1 to L5 and from R1 to R5, the percentage cover of each species is estimated by sight (e.g. % of a particular sub-plot occupied by *Cinnamomum v.*).

C1.2 Vegetation quality assessment

Here again we followed the methodology of Fleischmann (e.g. Fleischmann, 1997; Fleischmann et al., 2005; Gamatis and Fleischmann, 2016). We used ecological status matrices to infer the Protection Values (PtVs) of each of the 10 vegetation-monitoring sites. PtVs are quantitative values which refer to the vegetation quality, PtVs do not include herbaceous plant species and pteridophyte. The purpose of using these PtVs is to show the differences in the vegetation quality between the sites and to have a scientific basis when evaluating the outcomes of any rehabilitation intervention. In short: using PtVs in vegetation science is a quick and powerful way to assess and monitor the vegetation quality of a particular site before and after the vegetation rehabilitation.

To calculate the PtV of a particular site, the data collected along each transect (100 trees and 100 saplings) are classified according to Table C2. Endemic species are based on the IUCN Red Book status of Seychelles endemic plants (Huber and Ismail, 2007).

Table C2: Value classes given for each criterion, which are used for the ecological status matrices M1 to M3.

Criterion	Value Classes		
	1	**2**	**3**
Diversity of natives	< 8	8 – 16	> 16
Diversity of Endemics	< 5	5 – 10	> 10
Total abundance of exotics	> 60	30 – 60	< 30
Total abundance of natives	< 30	30 – 60	> 60
Native regeneration (No. Native saplings)	< 34%	34% - 66%	> 66%

Once done, we entered the values 1 to 3 (Table C2) into the corresponding matrices M1 to M4, following the concept shown in Table C3. In the first matrix M1, diversity of native species and diversity of endemics are combined, in M2 the abundance of native species and of exotics, in M3 the entries of M2 with native rejuvenation, and in M4 the entries of M1 with those in M3. The values in M4 are considered as PtVs which indicate the protection priority of a particular site with regards to woody plant species. The highest vegetation quality in terms of native species diversity, abundance of native and exotic tree species, endemism and native regeneration scored 5 (excellent), while the lowest PtV is assigned with 1 (poor).

Table C3: Ecological status matrices.
Note: Values in M1 to M3: 1=low, 2=medium; 3=high. Values in matrix 4 (protection values): 1=very low, 2=low, 3=medium, 4=high, 5=very high.

M1		Diversity of Natives		
		3	**2**	**1**
Endemics	**3**	3	3	2
	2	3	2	2
	1	2	2	1

M2		Abundance exotics		
		3	**2**	**1**
Abundance Natives	**3**	3	3	2
	2	3	2	2
	1	2	1	1

M3		Native Regeneration		
		3	**2**	**1**
M2	**3**	3	3	2
	2	3	2	2
	1	2	2	1

M4		M3		
		3	**2**	**1**
M1	**3**	5	4	3
	2	4	3	2
	1	3	2	1

In addition to PtVs, another method for assessing the quality of the vegetation was used, namely Vegetation Quality Index (VQI). This method was firstly introduced by Gamatis and Fleischmann, 2016. As for PtVs, the VQI of each transect was determined by using this formula:

$$VQI = (\log(\%a)) + (\log(\%r)) + (\log(\%e)) + (\log(\%n))$$

where a is the abundance of native (indigenous + endemic) trees in one transect (indicating the presence of native trees), r is the abundance of native saplings in one transect (indicating native regeneration), e is the number of endemic tree species (indicating singularity) in one transect, and n is the number of native tree species in one transect (indicating native species diversity).

C2 Results

C2.1 Vegetation analysis

In this section we will calculate the Prominence Values (PV), the Shannon-Weaver Diversity Indices (H'), the abundances of exotic trees, the tree densities, the tree dominances and estimate the ground cover within the 10 sites.

In Val d'Endor water catchment, 32 species of adult trees (26 broadleaf tree species and 6 palms) and 24 species of tree saplings (19 broadleaf saplings and 5 species of palm saplings) were found along the 10 transects investigated (APPENDIX G2, Table G3). In the permanent sampling plots, 19 species of adult trees (17 broadleaf tree species and 2 species of palms), 21 species of tree saplings (17 species of broadleaf saplings and 4 species of palm saplings), 19 species of tree seedlings and 5 species of herbaceous plants were recorded.

C2.1.1 Prominence of adults and saplings in the Val d'Endor watershed

The 16 most prominent woody species (in decreasing order of adult PVs) in the 10 transects are: *Cinnamomum verum, Tabebuia pallida, Chrysobalanus icaco, Phoenicophorium borsigianum, Adenanthera pavonina, Sandoricum koetjape, Memecylon eleagni, Ochna kirkii, Falcataria moluccana, Paragenipa lancifolia, Nephrosperma vanhoutteanum, Deckenia nobilis, Alstonia macrophylla, Diospyros boiviniana, Hevea brasiliensis,* and *Dracaena reflexa.* Out of these 16 species, 9 species are exotics, 1 is indigenous and 6 are endemics (see Table C4).

Table C4: Results of Prominence Values for adults and saplings of the 16 most prominent species found in the ten transect of the study area.
Note: The purple names stand for endemic species, blue for indigenous species, black for exotic species.

Species	PV (Adults)	PV (Saplings)
Adenanthera pavonina	11.81	14.86
Alstonia macrophylla	6.07	0.00
Chrysobalanus icaco	20.02	24.67
Cinnamomum verum	26.50	19.57
Deckenia nobilis	6.07	6.31
Diospyros boiviniana	5.52	3.64
Dracaena reflexa	5.10	10.88
Falcataria moluccana	6.71	1.31
Hevea brasiliensis	5.30	4.32
Memecylon eleagni	8.23	10.30
Nephrosperma vanhoutteanum	6.39	20.59
Ochna kirkii	7.26	15.88
Paragenipa lancifolia	6.61	5.92
Phoenicophorium borsigianum	16.02	28.76
Sandoricum koetjape	11.04	11.32
Tabebuia pallida	20.99	3.93

Table C4 shows the results of the different PVs for adults and saplings. The PVs apply to the whole watershed area and not to a specific vegetation monitoring site. The four most prominent adult species out of the 16 are *Cinnamomum v.* with a PV of 26.5, *Tabebuia p.* with a PV of 20.99, *Chrysobalanus i.* with a PV of 20.02 and *Phoenicophorium b.* with a PV of 16.02. The first three are exotic species while the latter one is endemic. The four most prominent sapling species are *Phoenicophorium b.* (endemic) with a PV of 28.76, *Chrysobalanus i.* (exotic) with a PV of 24.67, *Nephrosperma v.* (endemic) with a PV of 20.59 and *Cinnamomum v.* (exotic) with a PV of 19.57. One can see that *Chrysobalanus i.*, *Cinnamomum v.*, and *Phoenicophorium b.* are the most prominent species for both, adults and saplings. Figure C3 gives a better representation of the results from Table C4; it represents the Prominence Values of adults (x-axis) versus Prominence Values of saplings (y-axis). Regarding *Adenanthera p.* this research follows the status given by Francis Friedman (Flore des Seychelles), which considers this species to be exotic. The authors stick to Friedman's assumption until a convincing reasoning which may suggest a different status for this tree species is found.

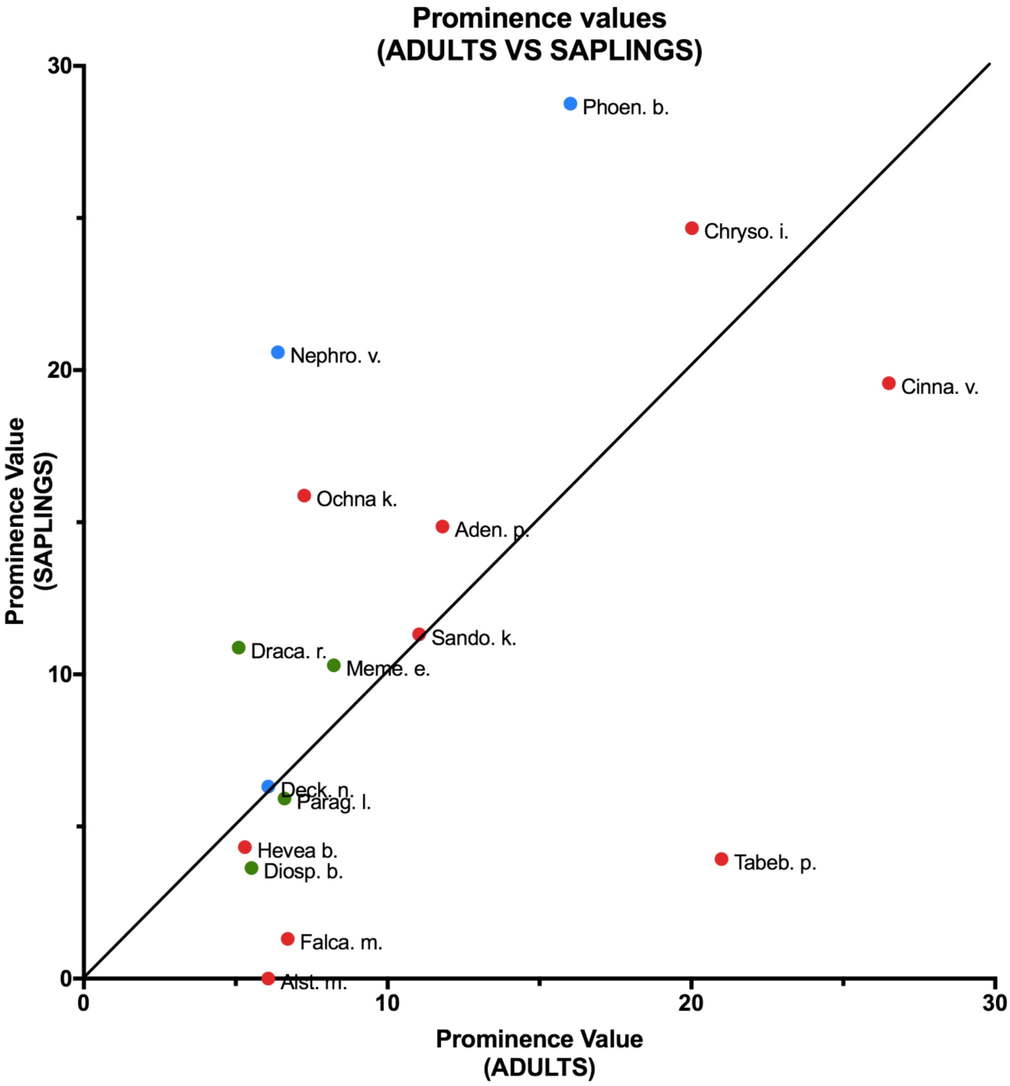


Figure C3: Prominence Values of adults versus saplings. The 16 most prominent woody species in the 10 transects of the study area are represented.
Note: The abbreviations are: Alst. m. (*Alstonia macrophylla*), Falca. m. (*Falcataria moluccana*), Diosp. b. (*Diospyros boiviniana*), Hevea b. (*Hevea brasiliensis*), Parag. l. (*Paragenipa lacifolia*), Tabeb. p. (*Tabebuia pallida*), Deck. n. (*Deckenia nobilis*), Meme. e. (*Memecylon eleagni*), Draca. r. (*Dracaena reflexa*), Sando. k. (*Sandoricum koetjape*), Aden. p. (*Adenanthera pavonina*), Ochna k. (*Ochna kirkii*), Nephro. v. (*Nephrosperma vanhoutteanum*), Cinna. v. (*Cinnamomum verum*), Chryso. i. (*Chrysobalanus icaco*), and lastly Phoen. b. (*Phoenicophorium borsiginamum*). The blue dots represent the endemic palms, the exotic species are the red dots, and finally the green dots stand for the native broad leaves species.

According to Fleischmann studies, the species above the 30/30 cut-off line in Figure C3 are those that are likely to increase their PVs in the watershed such as *Nephrosperma v.*, *Phoenicophorium b.* and *Chrysobalanus i.* They have a high rejuvenation rate. *Nephrosperma v.* and *Phoenicophorium b.* are endemic palms, while *Chrysobalanus i.* is an exotic species. All the species that are below the 45° line are likely to decrease as they have a lower PV of saplings compared to their respective adult PVs, so a sufficient regeneration of these species is not guaranteed. In general, one can see on the graph that the native regeneration is higher compared to exotic rejuvenation (Mann-Whitney U-test: p=0.01).

C2.1.2 Exotic species

Figures C4 and C5 show the abundance of adult exotic tree species vs. exotic tree sapling species in the ten monitoring sites investigated in the Val d'Endor watershed. We can see that only *Chrysobalanus i.*, *Sandoricum k.*, *Adenanthera p.* and *Ochna k.* are likely to increase in some areas of the watershed, while *Cinnamomum v.* and *Tabebuia p.* are likely to decrease (see below for more details). These 6 species are actually the 6 most prominent exotic species. If one wants to see distribution patterns and the magnitude of the invasion of these 6 species (only adult trees) in the ten sites of Val d'Endor watershed, please refer to APPENDIX G3 (Figure G1 to G6).

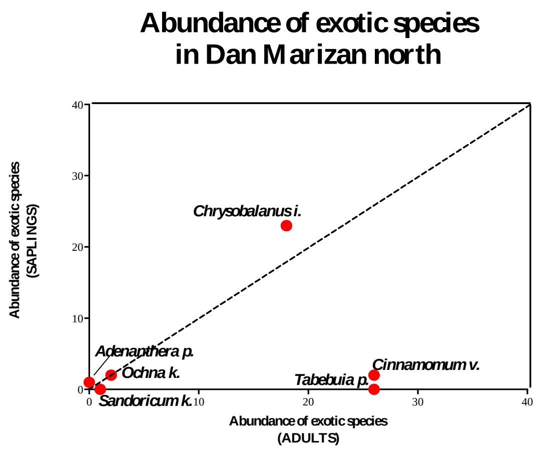
The occurrence of *Chrysobalanus i.* is estimated to increase in *Dan Merl*, in *Dan Karolin west*, in *Dan Tombalo low*, in *Dan Pinpin up*, in *Dan Karolin east*, in *Dan Teso*, in *Dan Marizan north* and finally in *Dan Marizan south*. As can be seen, *Chrysobalanus i.* has thus a high probability of increasing in abundance in the future.

Sandoricum k. is also likely to increase in the future in some areas: in *Dan Merl* and in *Dan Tombalo up*. In *Dan Pinpin low*, one can see on Figure C5 that *Sandoricum k.* might increase in abundance in this transect with only two saplings recorded. In *Dan Pinpin up*, it might stay constant. Otherwise, in all the other sites, this species is likely to decrease.

Adenanthera p. is likely to increase in *Dan Tombalo low* and in *Dan Pinpin up*, while it is likely to decrease in *Dan Merl*, *Dan Tombalo up*, *Dan Pinpin low*, *Dan Karolin east* and *Dan Teso*. In the *Dan Marizan north* transect, *Adenanthera p.* might increase in abundance.

Concerning *Ochna k.*, its occurrence is estimated to increase in *Dan Pinpin up*, in *Dan Tombalo low*, in *Dan Pinpin low*, in *Dan Teso*, and in *Dan Marizan north*. In some transects *Ochna k.* might increase in abundance; this is the case in *Dan Karolin west* which shows only 2 saplings, in *Dan Karolin east* with 6 and in Dan Marizan south with one sapling.

On these figures below one can see that *Cinnamomum v.* is present in all 10 transects, but is likely to decrease, as the abundance of tree saplings is always lower than the abundance of adults.



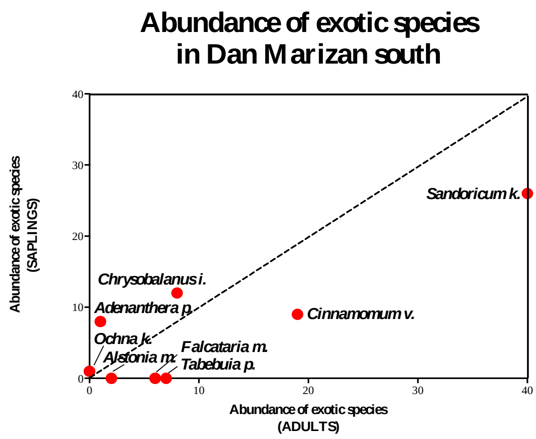


Figure C4: Abundance of exotic species (adult tree vs. tree sapling) in 2 different sites of Val d'Endor watershed. Note: The relations between the rel. abundance of adults vs. the rel. abundance of saplings allow an estimation of the future forest succession, i.e. species above the cut-off line are likely to increase in abundance.

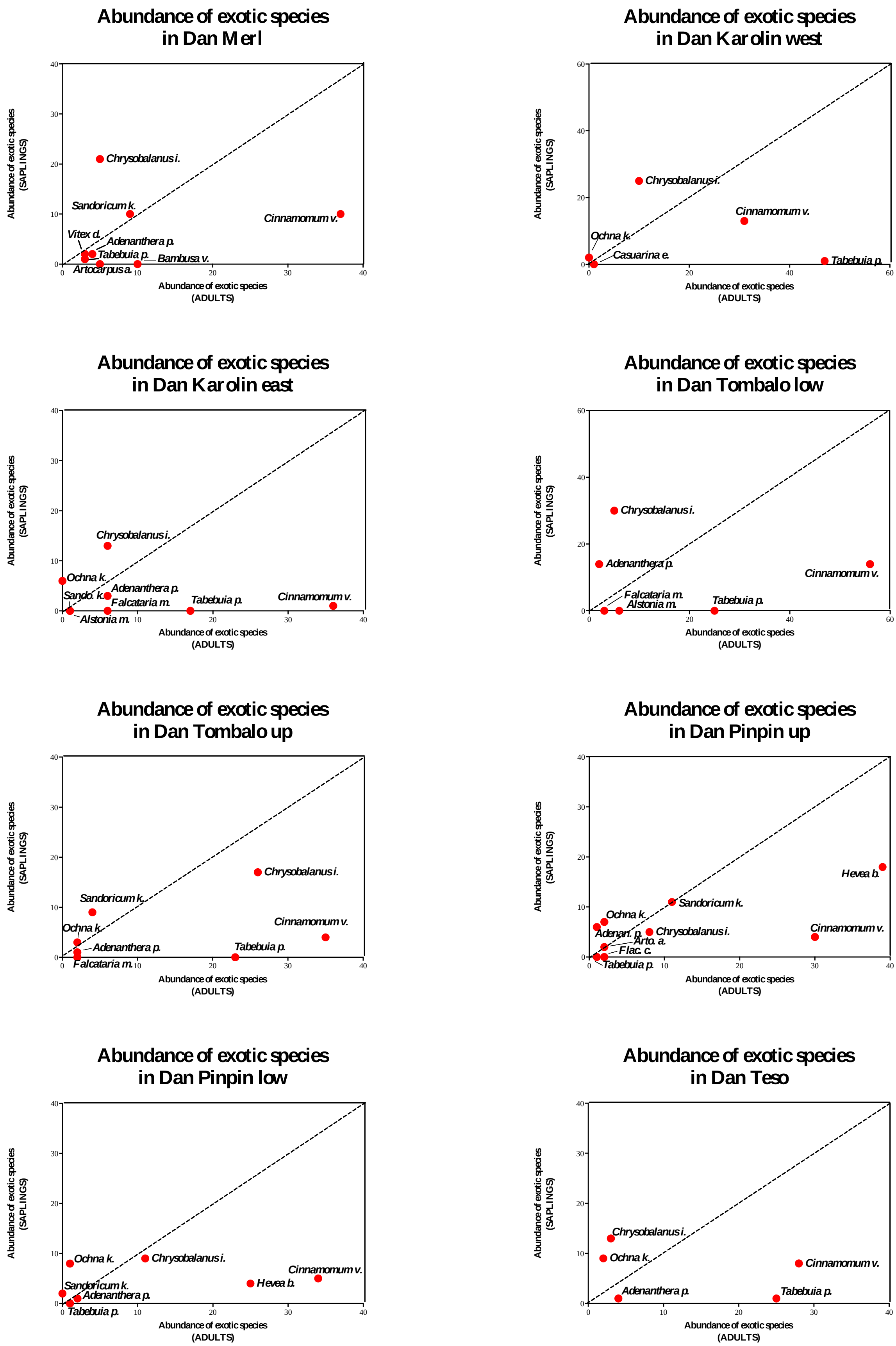


Figure C5: Abundance of exotic species (adult tree vs. tree sapling) in 8 different sites of Val d'Endor watershed. Note: The relations between the rel. abundance of adults vs. the rel. abundance of saplings allow an estimation of the future forest succession, i.e. species above the cut-off line are likely to increase in abundance.

C2.1.3 Species diversity of the Val d'Endor watershed

Dan Merl transect has 15 different adult species, out of which 9 are exotics, 2 are indigenous, and 4 are endemics (see APPENDIX G2, Table G4). It accommodates 10 sapling species, whereby 7 are exotics, 1 is indigenous, and 2 are endemics. The Shannon-Weaver Index for adult tree species equals 2.063 which is the highest in all monitoring sites (Table C5).

Dan Karolin west has 6 different adult species and 9 sapling species. The adult species are composed of 4 exotics and 2 endemics. The sapling species comprises 5 exotics and 4 endemics (see APPENDIX G2, Table G5). This transect has a Shannon-Weaver Index for saplings that equals 1.772 indicating that *Dan Karolin west* is the third diverse site for tree saplings (Table C5). For adult trees, it is below average.

Dan Tombalo low contains 9 adult species, which are all exotics. On the other hand, there are 8 sapling species, of which 4 are exotics, 2 indigenous and 2 endemics (see APPENDIX G2, Table G6). Both values of the Shannon-Weaver-Index (for adult trees and for tree saplings) are below average (Table C5).

Dan Pinpin up has 13 different adult species. Out of these 13, 10 are exotics, 1 is indigenous and 2 are endemics (see APPENDIX G2, Table G7). Concerning tree saplings, this site contains 10 species, out of which 7 are exotics, and 3 are endemics. The diversity of adults in this transect is below average (H'=1.684), while the diversity of saplings has the second highest score (H'=1.877) in the research area.

Dan Pinpin low has 7 adult exotic species, 1 adult indigenous species, and 3 adult endemic species, which makes a total of 11 species. There are 11 sapling species: 6 exotic species, 1 indigenous and 4 endemics (see APPENDIX G2, Table G8). Both Shannon-Weaver Indices (i.e. for adults and saplings) are slightly above their respective mean (Table C5).

There are 13 adult species in *Dan Karolin east*, out of which 7 are exotics, 1 is indigenous, and 5 are endemics (see APPENDIX G2, Table G9). This transect, on the other hand has 11 sapling species: 6 exotics, 1 indigenous, and 4 endemics. In terms of species diversity, this site has the highest result (H'=2.031) for adults, but for saplings the Shannon-Weaver Index equals 1.470, which is below average (Table C5).

Table C5: Shannon-Weaver Index in each transect for both adults and saplings.

Transects	Shannon-Weaver index for adults	Shannon-Weaver index for saplings
Dan Merl	2.063	1.662
Dan Karolin west	1.313	1.772
Dan Tombalo low	1.311	1.678
Dan Pinpin up	1.684	1.877
Dan Pinpin low	1.782	1.706
Dan Karolin east	2.031	1.470
Dan Teso	1.929	2.116
Dan Marizan north	1.987	1.541
Dan Marizan south	1.941	1.537
Dan Tombalo up	1.649	1.452
Mean	1.769	1.681

In Dan Teso, 10 adult species were encountered whereby 5 are exotics, and 5 endemics (see APPENDIX G2, Table G10). This site has 13 sapling species: 5 exotics, 1 indigenous and 7 endemics. This transect has high diversity for both adults and saplings: H'=1.929 and H'=2.116 respectively. The diversity for the adults is above average and shows the highest value of all 10 vegetation transects for saplings (Table C5).

Dan Marizan north is composed of 15 adult species: 6 exotics, 4 indigenous, and 5 endemics. It has 9 sapling species: 4 exotics, 2 indigeneous, and 3 endemics (see APPENDIX G2, Table G11). The species diversity for adults is the third highest (H'=1.987) in all transects, while for saplings the value is below average (Table C5).

The *Dan Marizan south* contains 13 adult species: 8 exotics, 3 indigenous, and 2 endemics. There are 11 sapling species out of which 5 are exotics, 3 are indigenous, and 3 are endemics (see APPENDIX G2, Table G12). The Shannon-Weaver Index is above average for the adult trees but not for tree saplings (Table C5).

In *Dan Tombalo up*, there are 9 adult exotic species and 1 endemic (in total 10 adult species). This last transect has 11 sapling species: 6 exotics, 2 indigenous and 3 endemics (see APPENDIX G2, Table G13). Both Shannon-Weaver Indices for both, adults and saplings, are below average (Table C5).

C2.1.4 Tree density and dominance in the catchment

The tree density (number of tree per hectare) and the dominance (DBH-cross sectional area m^2/ha), differs for each site (Table C6; Table C7; Figure C6). The density and dominance is organized in four size classes: (1) class I has trees with a DBH (diameter at breast height) between 3cm and 10 cm, (2) class II between 11cm and 30cm, (3) class III between 31 cm and 60 cm, (4) and finally class IV has trees with a DBH over 60 cm.

1. <u>Density</u>

Dan Teso permanent sampling plot is the one having the highest density of trees especially in the density classes I and II (Table C6). The permanent sampling plots in *Dan Tombalo low*, *Dan Pinpin low* and *Dan Tombalo up* (Figure C6) show a lower rate of regeneration compared to the other sites. On the other hand, site *Dan Pinpin low* and *Dan Tombalo up* reveal the highest class IV density of trees/ha.

While looking at the total density for the entire watershed (Table C6), one can see that from class I to class II, the number of individuals/ha increases and from class II to III to IV it decreases.

The tree density per hectare for each species is shown in Figure C7. *Cinnamomum v.* has the highest number of individuals/ha for trunk diameter of class II compared to the other species. *Tabebuia p.* has the highest density scores in the DBH class 30cm – 60cm and in the DBH class of >60cm. *Phoenicophorium b.* and *Deckenia n.* are present in the DBH classes II and III and *Nephrosperma v.* in class II only. Note that because palms have no secondary thickening their DBH should not be compared with those of broadleaf trees; i.e. any DBH comparison in palms is understood as intraspecific.

2. <u>Dominance</u>

Dan Tombalo up has the highest dominance of trees, followed by *Dan Marizan north* (Table C7), while *Dan Tombalo low* has the lowest one. For the density classes I and II, *Dan Teso* has the highest dominance of trees. Finally, *Dan Tombalo up* followed by *Dan Merl* have the highest dominance of trees for the class IV.

While looking at the dominance (Table C8) of each species found in the ten sampling plots, one can see that *Tabebuia p.* clearly dominates the watershed in terms of stem area at BH (dominance = 147.23 m^2/ha).

Table C6: Number of individuals per hectare for each sampling plot investigated in Val d'Endor watershed.
Note: The individuals are separated according to their DBH in four different DBH-classes. Also shown, the density/ha for the entire Val d'Endor watershed. The total represents the total number of individuals/ha (the four classes confounded).

DENSITY					
Permanent Sampling Plots	**Class I** (3cm – 10cm)	**Class II** (11cm – 30cm)	**Class III** (31cm – 60cm)	**Class IV** (> 60cm)	**Total**
Dan Merl	1040	360	240	120	1760
Dan Karolin west	800	320	1520	280	2920
Dan Tombalo low	120	120	440	40	720
Dan Pinpin up	280	400	200	200	1080
Dan Pinpin low	40	320	320	480	1160
Dan Karolin east	720	520	80	400	1720
Dan Teso	3160	4160	480	200	8000
Dan Marizan north	600	1040	1000	440	3080
Dan Marizan south	920	1120	240	160	2440
Dan Tombalo up	120	240	480	440	1280
Watershed	780	860	500	276	2416

Table C7: Basal area (DBH-cross sectional area m^2/ha); i.e. dominance of trees) indicating the size of tree biomass.
Note: The individuals are arranged according to their DBH in four different classes. Also shown is the basal area for the entire Val d'Endor watershed. The total represents the area of stem cross section in m^2/ha at BH of all four classes.

DOMINANCE					
Permanent Sampling Plots	**Class I** (3cm – 10cm)	**Class II** (11cm – 30cm)	**Class III** (31cm – 60cm)	**Class IV** (> 60cm)	**Total**
Dan Merl	3.88	10.02	37.14	301.74	352.79
Dan Karolin west	1.93	18.34	235.36	124.96	380.59
Dan Tombalo low	0.53	6.38	81.04	17.70	105.65
Dan Pinpin up	1.05	14.88	37.46	187.28	240.67
Dan Pinpin low	0.11	16.54	45.13	239.73	301.51
Dan Karolin east	3.43	13.73	7.49	277.14	301.79
Dan Teso	11.63	110.12	60.21	63.64	245.61
Dan Marizan north	2.53	36.02	147.52	203.71	389.78
Dan Marizan south	3.21	48.24	26.03	80.41	157.90
Dan Tombalo up	0.18	10.76	80.56	374.74	466.24
Watershed	2.85	28.5	75.80	187.11	294.25

Table C8: Tree dominance (DBH-cross sectional area m^2/ha) per size class for the most dominant species found in Val d'Endor watershed.
Note: The total represents the area of stem cross section in m^2/ha at BH of all four classes.

DOMINANCE OF SPECIES					
Species	**Class I** (3cm – 10cm)	**Class II** (11cm – 30cm)	**Class III** (31cm – 60cm)	**Class IV** (> 60cm)	**Total**
Cinnamomum v.	0.87	10.91	20.26	5.85	37.89
Deckenia n.	0.00	1.07	4.35	20.34	25.76
Nephrosperma v.	0.00	3.93	0.00	0.00	3.93
Phoenicophorium b.	0.00	0.69	6.52	0.00	7.21
Tabebuia p.	0.09	3.47	39.75	103.91	147.23
Adenanthera p.	0.16	0.07	0.00	19.68	19.91
Arthocarpus a.	0.03	0.00	0.00	30.17	30.17

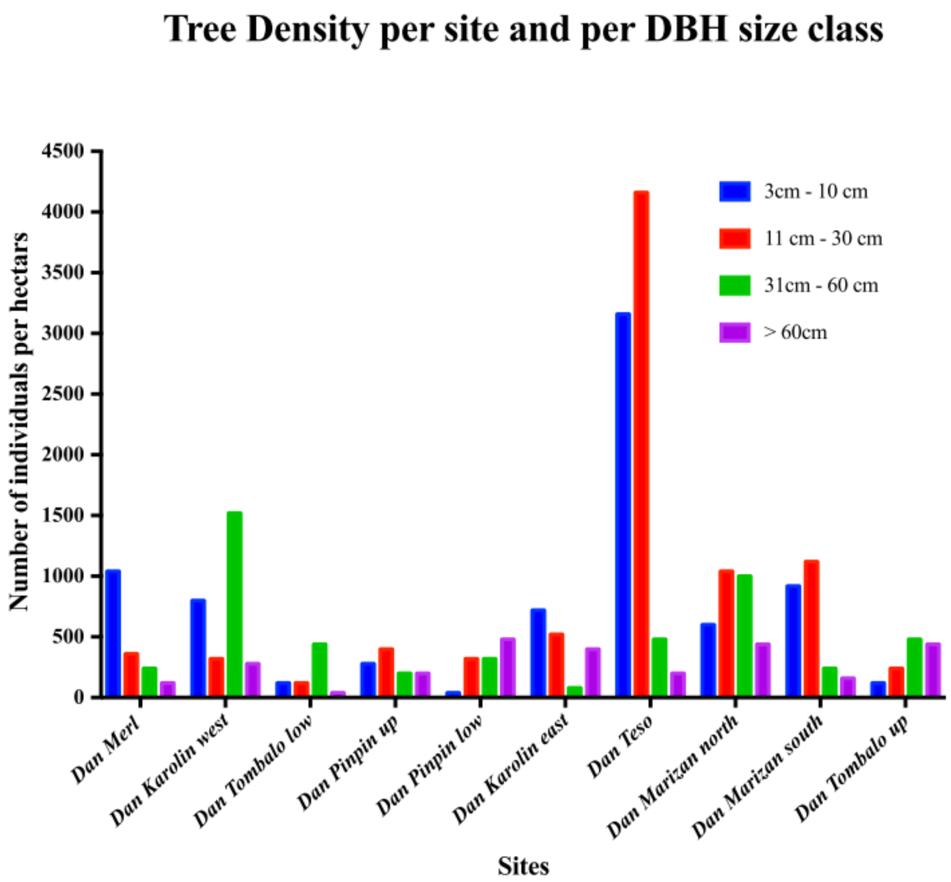


Figure C6: Graph representing the tree density (number of trees per hectares) in each of the ten permanent sampling plots investigated.
Note: The tree density is divided into 4 DBH-classes.

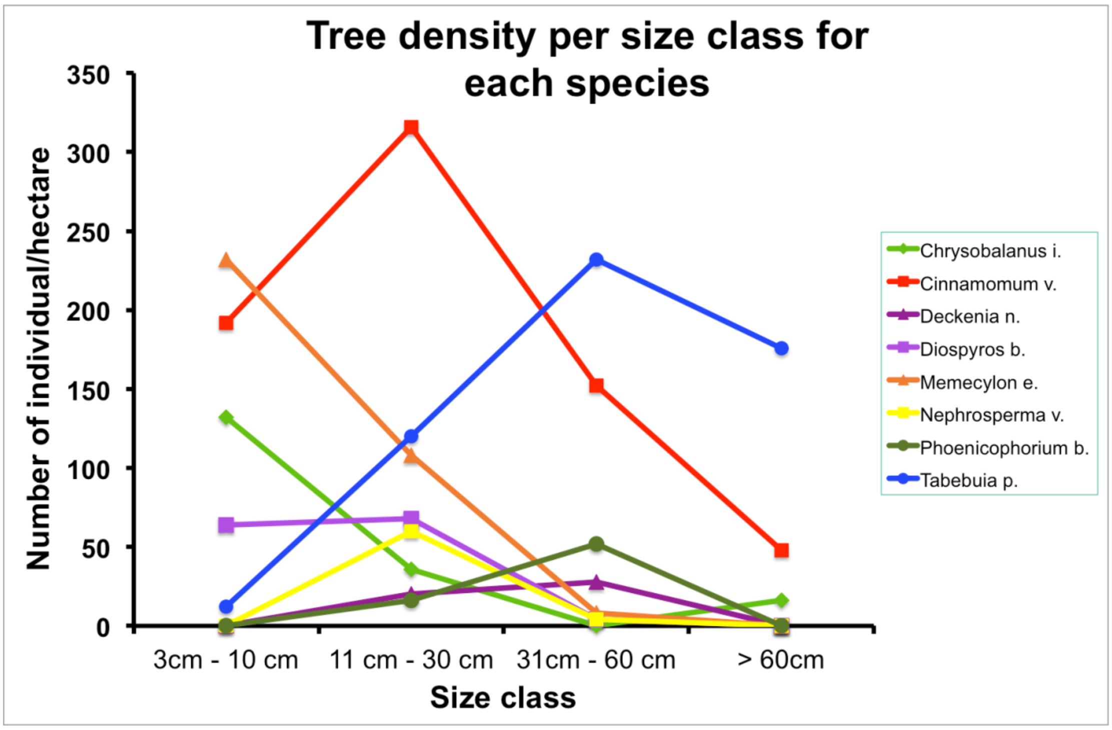


Figure C7: Graph showing the density distribution of 8 species in Val d’Endor water catchment.
Note: The tree density is divided into 4 DBH-classes.

C2.1.5 Ground cover

The ground cover (%) was calculated for each permanent sampling plot (Table C9). As it can be seen in Table C9 (I) the seedlings of woody tree species are *Adenanthera p*., *Cinnamomum v*., *Chrysobalanus i*., *Deckenia n*., *Memecylon e*., *Nephrosperma v*., *Ochna k*., and *Phoenicophorium b*. (II) the known herbaceous species is *Merremia p*. and (III) the unknown herbaceous species are made of the rest of the whole vegetation spectrum within the permanent sampling plot. The so-called « uncovered area » comprises bare soil, rock, rivers, etc. In this table we listed only those species with the highest ground cover scores. The woody species showing the highest (14.7%) vegetation cover are seedlings of *Cinnamomum v*. followed by those of *Phoenicophorium b*. and *Adenanthera p*. In some sites, the highly invasive *Merremia p*. was found (permanent plot *Dan Pinpin low* and *Dan Marizan south*), although in small numbers.

Table C9: Ground cover (%) for different species in each permanent sampling plot (125m^2).
Note: The « uncovered area » represents bare soils, rocks, rivers, etc. Also present in this table, is the ground cover of unknown herbaceous plant (usually grasses). The sites from PP1 to PP10 are: (PP1) *Dan Merl*, (PP2) *Dan Karolin west*, (PP3) *Dan Tombalo low*, (PP4) *Dan Pinpin up*, (PP5) *Dan Pinpin low*, (PP6) *Dan Karolin east*, (PP7) *Dan Teso*, (PP8) *Dan Marizan north*, (PP9) *Dan Marizan south*, and (PP10) *Dan Tombalo up*.

	PP1	PP2	PP3	PP4	PP5	PP6	PP7	PP8	PP9	PP10	Mean
Adenanthera p.	0	0	0.25	26.1	23.3	6.1	0.1	2.61	0.7	0	5.9
Cinnamomum v.	22	13.5	45.9	15.9	19.2	0	6.9	19.6	1.3	3.6	14.7
Chrysobalanus i.	3.5	0.7	0.2	0.5	0	0.1	0.6	0.51	0	0	0.6
Deckenia n.	0	1.1	0	1.5	1.6	0	0.11	0	0	0	0.4
Memecylon e.	0	2.04	0	0.1	0	0	14.6	0.7	0	0.1	1.7
Nephrosperma v.	0	1.76	1.8	0	0	1	2.8	5.6	2.4	7.1	2.2
Ochna k.	0	0.5	0.2	1	0.1	0.3	0.8	0.1	0.1	0	0.3
Phoenico. b.	5.6	19.3	12.2	6.6	1.6	5.3	3.3	0.31	1.1	16	7.1
Merremia p.	0	0	0	0	0.9	0	0	0	0.2	0	0.1
Unknown herbaceous	24.5	1.2	1	0	0	28.2	0	3	0.1	2	6
Uncovered area	0	11.5	6.5	15	23.7	11.3	11.2	23.3	22.1	2	12.6

C2.2 Vegetation quality assessment

In order to assess the quality of the vegetation in the Val d'Endor water catchment, we used Protection Values (PtVs), considering woody plant species only, which are determined depending on the species diversity of natives, the number of endemic species, the total abundance of exotics, the total abundance of natives and finally the native regeneration (see methods). A PtV of 1 shows a low vegetation quality (based on the above-mentioned parameters), while a PtV of 5 represents a high vegetation quality.

In the watershed, the PtVs vary between 1.5 and 4 (Figure C9). In terms of PtV, *Dan Tombalo low* has the lowest score accommodating only exotic adult trees. We decided to lower the PtV from 2 to 1.5 because there are neither indigenous nor endemics. Out of the ten areas investigated, five of them have a PtV of 2 (*Dan Karolin west*, *Dan Pinpin up*, *Dan Pinpin low*, *Dan Marizan south* and *Dan Tombalo up*). Usually a PtV score of 2 shows only little species diversity of indigenous and endemic species, but a high abundance of exotic. *Dan Marizan north* and *Dan Karolin east* have both a PtV of 3. This means that the quality of the vegetation in these areas can be qualified as "not too bad"; they both show a high percentage of native regeneration (especially palms) and a decent number of indigenous and native tree species. On the other hand, they both have a very high abundance of exotics. We decided to increase the PtV in site *Dan Merl* from a PtV of 2 to a PtV of 2.5 because for both endemic and native species, the species diversity is close to the upper cutoff value. Finally, *Dan Teso* shows the highest PtV score (PtV=4). This forest site has indeed a quite high rejuvenation rate and the abundance of native tree species in this site is bigger compared to all other areas.

On the map (Figure C9), polygons of different colors represent forest areas which are considered to be homogenous in terms of forest structure and species composition.

In addition to PtVs, a Vegetation Quality Index (VQI) has been introduced for the first time in the Seychelles by Gamatis and Fleischmann, 2016:

Table C10: Vegetation Quality Index in each transect.
Note: The transects from 1 to 10 correspond to: (1) *Dan Merl*, (2) *Dan Karolin west*, (3) *Dan Tombalo low*, (4) *Dan Pinpin up*, (5) *Dan Pinpin low*, (6) *Dan Karolin east*, (7) *Dan Teso*, (8) *Dan Marizan north*, (9) *Dan Marizan south*, and (10) *Dan Tombalo up*.

Transects	1	2	3	4	5	6	7	8	9	10
VQI	4.19	3.13	1.74	2.65	4.05	4.51	4.53	4.65	3.57	1.54

The VQI scores correlate highly significantly with the PtVs of the ten vegetation monitoring sites (Spearman Rank Correlation: r=0.876, p=0.001). This correlation is further confirmed by employing the "moving average" as shown in Figure C8. Since the VQI method is less time consuming to perform, it might be a valuable alternative to assessing the vegetation quality by means of Protection Values.

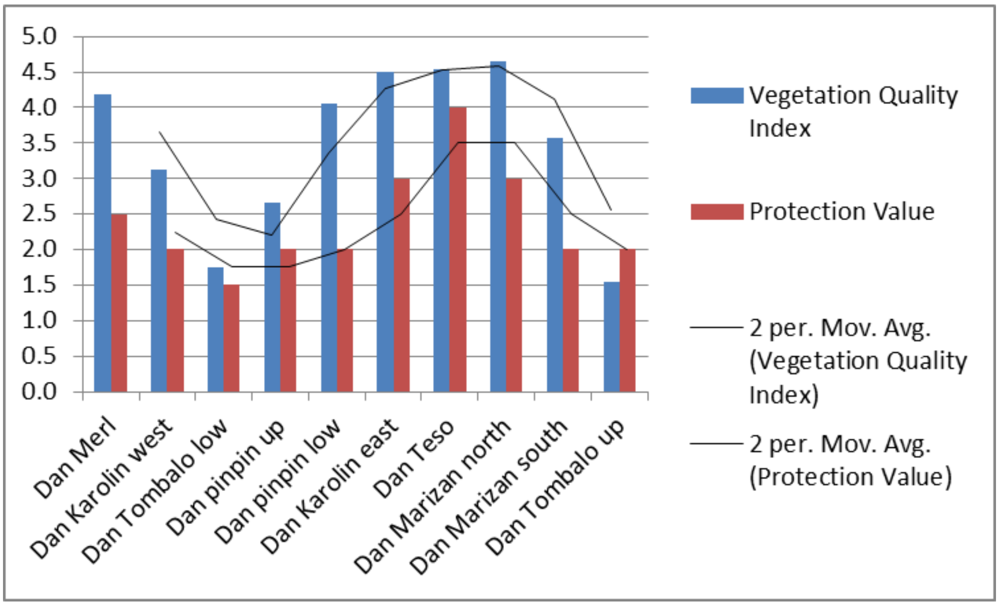


Figure C8: Moving average of VQI and PtVs in the ten sites of Val d'Endor watershed.
Note: They reveal a highly significant correlation (Spearman Rank Correlation: p=0.001)

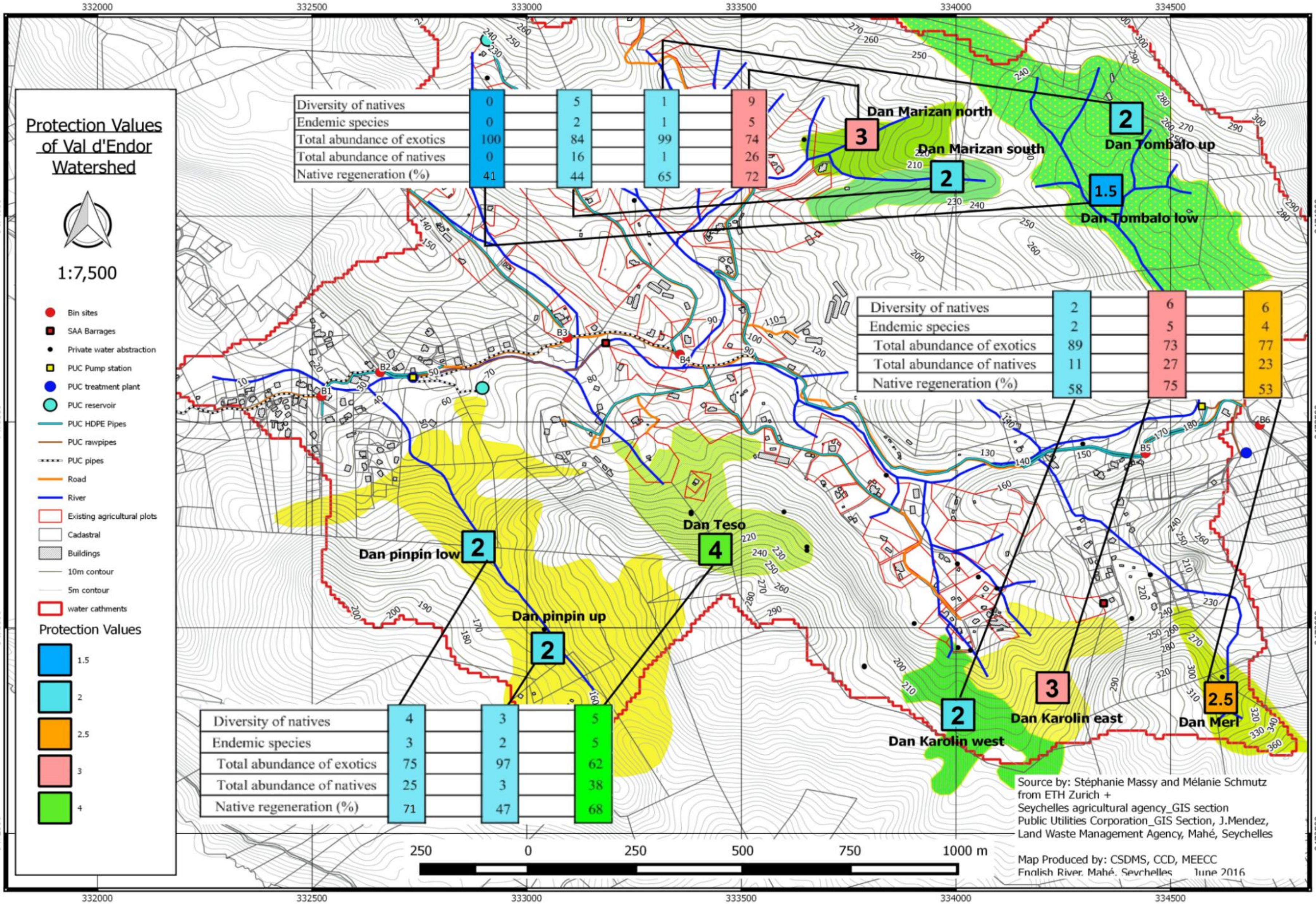


Figure C9: Protection values for the Val d'Endor water catchment.

C3 Discussion

In this section, we will first present (1) a background on watershed rehabilitation, followed by discussion on (2) the distribution of invaders and natives, and on (3) the patterns of invasion in each site.

C3.1 Background on watershed rehabilitation

Invasive species are widely accepted as one of the major direct causes of biodiversity loss. Also, it is well known that invasive species have big effect on native biodiversity, cause huge economic lost and complicate the management of ecosystems around the world. Exotic species take over native species all around the world (Didham et al., 2005). The dominance of alien species is a consequence of competitive exclusion of native species. A model done by Didham et al. (2005) which describes the drivers of ecological change in degraded systems, predicts that experimental removal of dominant exotic species should result in recovery of native species. An experiment demonstrated that native seedling survival was possible even with high surrounding exotic cover but survival was significantly higher by removal of alien species (ibid.). Also, some native species showed a significant increase in per cent cover or productivity after the removal of exotic species. Although, the causes of native population decline are species specific and dependent on the context (ibid.). Those findings only highlight the benefit in term of biodiversity. One must also focus on the impact of alien species on hydrology of the watershed. There is a highly complex and controversial question of a possible impact of alien versus native plants on water flow and surface water resources in Seychelles water catchments, indeed the effects on hydrology remain unknown. A study showed that soil hydrological properties are not related to native vs. exotic status (Yamomoto and Anderson, 1967). Also, there is no proof that replacement of natives with alien species will affect hydrological function, however it has been shown that afforestation of semi-arid grassland would reduce water yield and stream flow particularly in the dry season (Ataroff and Rada, 2000). If there is indeed an impact of alien plants on surface water resources on a species or stand level in the Seychelles, increased evapotranspiration rates of exotics caused by an increased leaf-area index would, among other factors (see below), probably be the main driver. Edwards et al. (2015) recommend reducing the basal area in the watershed by a minimum of 15 to 20 percent to induce an increase in annual stream flow in a forested watershed. Plus, basal area is a good surrogate for leaf area, which is correlated with evapotranspiration. On the other hand, one must know that the removal of woody species can lead to massive erosion only decades after their removal, because woody roots persist in the soil (Strayer et al., 2006).

There is currently a complete lack of data in Seychelles regarding the impact of alien plants on surface water resources. Thus, it would be unscientific and not wise to assume that by removing exotic tree species the water flow in Seychelles watersheds would increase. For instance, we know that (I) the precipitation intercept of relevant species (exotic or native) plays an important role in the hydrodynamics of a forest, (II) the canopy wetness shapes evapotranspiration, (III) the leaf structure greatly influences canopy effects, (IV) the morphology of trees has a significant impact on the intercept capacity to rainfall, (V) the sap-flow rate of exotic vs. native species in Seychelles needs to be known, (VI) the root structure and root depth of relevant species in watersheds is crucial to understand the trees' water demand. Such questions are subject of research and need to be addressed prior to issuing statements and recommendations in the framework of this project.

Ecosystems that differ in composition and/or function from the present or the past systems are defined as novel ecosystems (Hobbs et al., 2009). They are a consequence of a change in species composition primarily due to invasive species or climate change (ibid.). Novel ecosystem management temporarily utilizes the “benefits” of exotics species. A study by Kueffer et al. (2010) shows that the best way to manage novel ecosystems invaded by *Cinnamomum v.* is to create small gaps of a few meters in diameter in the forest and seeds native species. The level of shade and root competition from surrounding adult *Cinnamomum v.* trees seem to support the seedlings of native species over invasive species. Removing massively adult trees and creating gaps in the forest tend to strongly favour some invasive species which are particularly fast growing, and may then fill gaps before native trees establishment (ibid.). One should know that the novel ecosystem concept is not in contradiction with old conservation strategies (i.e. preventing and containing non-native invasion), it rather takes changing management challenges into account on ecosystems impacted by anthropogenic activities (Kueffer et al., 2013).

All of these highlights show us that taking concrete decisions on forest rehabilitation of a watershed is not easy. The objective of the EbA project which seeks to maintain and enhance the forest water provisioning services through reforestation and removal of invasive alien species and re-colonize with native plants may not guarantee an increase in water flow. However, it will, even without the complete approval of scientific expert, have a significantly positive effect on the ecosystem services of the watershed at Val d’Endor. Studies on the impact of alien plants on surface water resources would take decades and water shortage due to badly managed forests and climate change might affect Seychelles very soon.

C3.2 Distribution of invaders and natives

From our results, we have seen that forest succession is greatly influenced by alien invasive plants. We have found 21 alien tree species along the 10 transect lines. In the whole watershed, *Cinnamomum v.*, *Tabebuia p.* and *Chrysobalanus i.* are the most prominent exotic species. We have seen that other species, which are less prominent, can also influence greatly the watershed vegetation. Those are *Adenanthera p.*, *Ochna k.*, and *Sandoricum k.* They showed the highest difference of abundance of saplings versus adults.

While the status of the species above is approved by scientific community, there are still some conflicts concerning the status of *Adenanthera p.* which is considered as exotic in this thesis. There are several reasons why *Adenantera p.* would have been introduced to the Seychelles. For instance: *Adenanthera p.*is a valuable timber, it provides hard reddish wood, much liked by settlers, and gives red dye obtained from its wood. *Adenanthera p.* is native from South-East Asia and Malaysia and (according to “People and Plants of Micronesia” publ. University of Hawaii) is possibly an introduction to parts of Melanesia. It is considered to have been recently introduced to Hawaii and elsewhere. Assuming that this assumption is correct (i.e. introduced, and not native to Hawaii), why should one assume that it is indigenous to the Seychelles? Another reasoning, which does not suggest an indigenous status, is that *Adenantera p.* is not generally found on atolls.

Cinnamomum v. is the most prominent species in the area. We have seen that this species was found in high abundance in most of the transects. Plus, ground cover estimation showed that it is the most prominent tree seedling (i.e. height <50 cm).

Comparing PVs of adult trees with saplings is a straightforward method to estimate forest succession; however it is important to appreciate that the precision of such estimation depends, among other factors, on the mortality rate of saplings which need appropriate studies.

By comparing the PVs of adults versus saplings, *Cinnamomum v.* is likely to decrease in the survey area in the future as there are fewer saplings than adults. The colonization of *Cinnamomum v.* is thus as a whole likely to decline in the Val d’Endor forest. According to other research (Bader and Hendry, 2007) “carpets” of *Cinnamomum v.* seedlings are likely to die-back, especially under low light levels.

In that sense, *Cinnamomum v.* does not seem to be the major problem for the watershed. Rehabilitation action should focus on exotic species that are likely to increase in abundance such as *Chrysobalanus i.* or on recent invaders such as *Adenanthera p., Ochna k.* or *Sandoricum k.*

Tabebuia p. and *Chrysobalanus i.* are moderately widespread in the watershed. *Tabebuia p.* is highly abundant in *Dan Karolin west* and shows medium abundance in *Dan Teso, Dan Karolin east, Dan Marizan north, Dan Tombalo up* and *Dan Tombalo low*. Fortunately, it seems that this species is likely to decrease in all 10 sites. Nevertheless, this tree clearly dominates the watershed in terms of DBH-cross sectional area m2/ha (*Cinnamomum v.* comes second but way behind *Tabebuia p.*). On the other hand, *Chrysobalanus i.* is likely to increase in the majority of the sites investigated. This species should be given special attention for rehabilitation.

Adenanthera p., Ochna k. and *Sandoricum k.* are not yet widespread in the area. *Sandoricum k*. is present in 6 transects and is highly abundant in only one of them (*Dan Marizan south*). *Ochna k.* is present in half of the transects with low abundance and *Adenanthera p.* is present in the majority of the transects with low abundance. Those tree species have newly recruited in some transects, meaning they could become problematic in the future if no action is taken. Those species can spread quite rapidly following similar invasion patterns like *Chrysobalanus i.* or *Cinnamomum v.*

Merremia p. and *Clidemia h.* became serious invaders of native plant communities in Seychelles. A study by Katulic et al. (2005) shows that a high diversity of alien creepers can be found along roadsides on Mahe. Indeed, there is a correlation between the number of habitations and the abundance of creepers, which indicates that gardens are a major starting point for creeper invasions. In all of our 10 transects, the occurrence of *Merremia p.* is still very restricted as we have selected area which show potential for rehabilitation, thus are not yet invaded with creepers. Plus, *Clidemia h.* was not found in our transects. Outside the 10 monitoring areas there are sites already completely invaded by *Merremia p.* That is why if no special attention is given to these creepers, they could invade the whole watershed very rapidly.

Concerning native species, we have found 15 species along the 10 transects. *Phoenicophorium b.* and *Nephrosperma v.* are highly represented in the whole watershed. *Phoenicophorium b.* is present in the majority of the transects and has the highest prominence values of all tree saplings. This palm shows a great potential to maintain and establish itself in areas seriously affected by forest destruction and topsoil erosion (Fleishmann, 1997). Both endemic palms are likely to increase in the future. Their high PVs indicate the very promising prospect that these plants are an excellent means for reforestation in highly disturbed and denuded areas (Fleishmann, 1997). Also, *Memecylon e.* and *Dracaena r.* are likely to increase even if they are less prominent than the two endemic palms presented above. These native species deserve special attention for rehabilitation and reforestation.

A principal component analysis by Fleischmann (1999) showed that the demographic score (i.e. annual increase in leaf area index, height, recruitment rate etc. as a measure of plant fitness) of *Phoenicophorium b.* is significantly higher compared to *Cinnamomum v.* at low light levels (i.e. below 15% diffuse site factor). Most of our transects show medium to high canopy with (in general) little canopy openness. In that sense, *Cinnamomum v.* which is a fast-growing and light demanding plant, does not seem to be able to increase its prominence in the future in Val d'Endor, whereas *Phoenicophorium b.* which seemingly prefers this type of habitat is on the increase. As already mentioned, *Phoenicophorium b.* can grow with very low levels of light and thus is successfully competing with *Cinnamomum v.* in the watershed. The study also states that endemic palms can probably compete with other invaders like *Adenanthera p., Tabebuia p., Hevea b.,* etc. in shaded forest areas. These results should be used to reduce the invasion of alien plants in Val d'Endor watershed.

C3.3 Patterns of invasion in each site

The most invaded area by exotic species is *Dan Tombalo low* with a 100% abundance of exotic adult species listed along the transects. This is reflected by the lowest all-over Protection Value (PtV) of 1.5 for *Dan Tombalo low*. *Chrysobalanus i.* and *Adenanthera p*. could become a major problem in the future as they are likely to increase in abundance.

Five other sites, with a PtV of 2, are heavily invaded as well and they present only few native adult trees (*Dan Tombalo up*, *Dan Marizan south*, *Dan Pinpin up*, *Dan Pinpin low* and *Dan Karolin west*). In *Dan Tombalo up*, a focus should be made on *Sandoricum k.* and *Ochna k.* The species *Chrysobalanus i.*, *Ochna k.* and especially *Adenanthera p.* could be a future problem in *Dan Marizan south*. *Adenanthera p.* and *Ochna k*. could increase in *Dan Pinpin up*. *Sandoricum k.* and especially *Ochna k.* should be the target for rehabilitation in *Dan Pinpin low*. Finally, *Ochna k.* and particularly *Chrysobalanus i.* are increasing in *Dan Karolin west* and should be the target species for rehabilitation.

In another monitoring site, *Dan Merl*, which has a PtV of 2.5, *Chrysobalanus i.* and *Sandoricum k.* are likely to increase in abundance. As these 7 sites show little abundance and species diversity of native adults trees, it surprising that they all present a high native rejuvenation especially by *Phoenicophorium b*. This demonstrates that even if the present vegetation quality can be qualified as "very bad" in terms of native species diversity, the sites often demonstrate an amazing resilience regarding the rejuvenation pattern of native tree species. It is assumed that this mechanism could have a positive effect on the future vegetation quality, when these saplings will have reached the adult stage.

Two transects have a PtV of 3 (*Dan Marizan north* and *Dan Karolin east*) which shows a medium vegetation quality with a very high rates of native rejuvenation, especially with *Phoenicophorium b.* and *Nephrosperma v*. The invasion of alien species in these areas is still quite high. In *Dan Marizan north*, *Chrysobalanus i., Adenanthera p.* and *Ochna k.* should be managed precociously in order to maintain the vegetation quality or to improve it. *Chrysobalanus i.* and *Ochna k.* should be the target for decision makers in *Dan Karolin east*.

Finally, *Dan Teso* has the highest PtV. About 40% of the total abundance of adult trees are native species (highest abundance of the adult native species are *Phoenicophorium b.* and *Diospyros b.* with a relative abundance of 13% for both species) and the native rejuvenation is also very high due to a high abundance of *Phoenicophorium b.* and *Memecylon e.* saplings including a few juvenile *Diospyros b., Deckenia n.* and *Nephrosperma v.* In the *Dan Teso* area, there is considerable concern about the future of its vegetation quality as *Chrysobalanus i.* and *Ochna k.* show a very high likelihood of increase compromising the quality of the area in the future.

In conclusion, a specific attention should be given to the sites having a PtV above 2 (*Dan Merl*, *Dan Marizan north*, *Dan Karolin east* and *Dan Teso)* in order to preserve or improve their vegetation quality. *Dan Merl* is situated partly on private land; nevertheless, the three remaining sites are situated on state land making rehabilitation procedures easier to conduct.

C4 Limitation

The methods used for the vegetation analysis and assessment are straightforward and have been approved in other vegetation studies in the Seychelles. No major limitations concerning these methodologies have been found. There are, nevertheless some constraints that could have had some impacts on our results. First, the ground cover estimation could contain some mistakes concerning the percentage of seedling coverage because it was estimated by sight. Its estimation is thus subjective. Furthermore, the counting of saplings was sometimes difficult in the PPs because some of them had a very high density. The identification of species for the 10 transects was done with the help of a local specialist. This should warrant the absence of any major mistake. Concerning the identification of all additional species, it is possible that the list is not complete as they were identified by looking around in the forest while performing the 100 enumerations on the transect lines. Another limitation would be the generalization of the transects and permanent plots data to the overall state of the forest in the Val D'Endor watershed. The Vegetation Quality Indices are just an indication of the quality of the forest and should be taken as such.

C5 Recommendations

Our main focus for the rehabilitation of the Val d'Endor watershed is to restore the capacity of degraded forest-land to deliver forest services and assist natural regeneration of native plant and animal species. We would also give advice on the development of the area as to best manage water supply in general.

Concerning the management of the forest, the aim of the rehabilitation is to strengthen the resilience of forest-landscapes in the Val d'Endor watershed and thereby to keep future land-use and management options open. We suggest to re-establishes the original productivity of the forest and some, but not necessarily all, of the plant and animal species to be originally present at a site. Both are implemented on sites or in landscapes where forest loss has caused a decline in the quality of environmental services, e.g. through invasive alien plants. An appropriate management will depend on the underlying mechanisms, which drive the decline of native species (Didham et al. 2007).

A logical activity would be to maximize genetic, species, and functional diversity wherever possible to produce a higher probability for the viability of water catchment plant communities; this might imply in a first rehabilitation phase to not just removing species that are not desired in the first place. Forest rehabilitation may be carried out on selected Val d'Endor forest sites by measures to assist natural regeneration (e.g. through the control of creepers (e.g. Merremia, Epipremnum etc.) and invasive woody tree species), and by measures to accelerate natural recovery by direct seeding or by planting seedlings.

D. Part II - Human impact and human perceptions analysis on ecosystem services

D1 Methods

D1.1 System analysis and scenario development

In this section, the methods used for analysing the system (D1.1.1 to D1.1.4), i.e. the Val d'Endor watershed (B), and for developing scenarios (D1.1.5) are presented. The scenarios were then used for the scenario evaluation (see methods, D1.2).

In order to analyse the system and develop scenarios, we identified (1) the ecosystem services of the Val d'Endor water catchment and their users. We (2) described the current state in terms of the ecological, social and infrastructural elements, as well as land use practices which qualify the catchment area and which can ultimately have an impact on the ecosystem services present in the water catchment. Plus, we (3) identified system descriptors which were used for (4) analysing the system's dynamic, and finally we (5) constructed scenarios.

D1.1.1 Ecosystem services and users

To structure our thesis and to appropriately integrate the different functions the Val d'Endor area fulfils, we followed the ecosystem services approach (MEA, 2005; De Groot et al., 2002; Boyd and Banzhaf, 2007; Farber et al., 2002; Wallace, 2007). Accordingly, we first reviewed pertinent scientific literature with a special focus on water supply and retention services. Based on the most relevant references (Brauman et al., 2007; Boyd and Banzhaf, 2007; Green et al., 2015; Ponette-González et al., 2015; Böck and Oberdiek, 2013; Hellsten et al., 2015; Quayle and Pringle, 2014; Brabec, 2009; Jewitt, 2002) we identified and selected those ecosystem services of the Val d'Endor which are related to our main focus: water provision and retention, and which at the same time contribute to residents' well-being which is a state characterized by health, happiness, and prosperity. Finally, experts verified and validated our list of ecosystem services.

Ecosystem services are strongly linked to users. Accordingly, we needed to know who the users are, what services they use and to what extent. In addition to this, we also wanted to know if, and if so to what extent, the users compete in terms of the different services provided by nature. Users are called stakeholders in this thesis. For the purpose of this study we define stakeholders as persons being affected or having an effect on the system (Clark, 2002), which is the watershed area of Val d'Endor delimited spatially by natural boundaries, i.e. ridge lines or watershed lines surrounding the Baie Lazare River, and temporally between now (current state) and in 30 years (future state).

In order to identify them, research on the Internet was done at first, followed by observation in situ. More precisely, we first identified all ministries, parastatal agencies, non-governmental agencies, and other groups that have a role to play directly or indirectly in the state of the watershed. Experts working on the EBA project at the Program Coordination Unit validated our preliminary stakeholder list to check whether we had a complete picture of stakeholders affected by or impacting the issue at hand. In addition, we analysed stakeholders' interests, and particularly the relationships among them to learn about areas of potential consensus or dissension which was guiding for the evaluation of the current and potential upcoming management strategies for the Val d'Endor watershed area.

D1.1.2 Current state

Any management strategy must be based on a sound knowledge basis. This is the reason one needs to clearly define the system that will be evaluated (Hein et al., 2006). Therefore, in order to have a full picture of the current state, we investigated the ecological, infrastructural and social elements, as well as land use practices. More precisely, we looked at (1) the topography, (2) land allocation, (3) housing, (4) agriculture, (5) waste management, (6) water management, (7) climate, (8) forest, (9) connectivity, (10) environmental protection, (11) health protection, (12) law enforcement, and (13) legal context. These 13 categories were identified by studying reports, reading scientific literature, reading government documents as well as informal talks, field observations, interviews and brainstorming guided by the question: what elements may have an influence on water provision and retention? To complete knowledge gaps and to validate and discuss our preliminary category list we interviewed eight institutions and stakeholder groups: Seychelles Agricultural Agency (SAA), Ministry of Land Use and Housing (MLUH), Ministry of Environment, Energy and Climate Change (MEECC), Public Utilities Corporation (PUC), Public Health Authority (PHA), Seychelles meteorological services (MET), Landscape and Waste Management Agency (LWMA), and watershed committee (for more details on stakeholders, see results, section D2.1.1).

With the support of the MEECC, a GIS based map was created which illustrates the current situation of the Val d'Endor. The map encloses the Baie Lazare River and all its tributaries, roads, housing, land use, wetlands, water infrastructures (barrages, water abstraction points, treatment plants) and other issues of interests (e.g., dumping sites) (see Figure D3 p.30).

D1.1.3 System descriptors

System descriptors are variables that describe the structure, characteristics and the dynamic of a system (Bossel, 2007; Vester, 2012). Depending on the complexity of a system the number of these descriptors can vary. They can represent objective facts or values, be quantitative or qualitative, and can change over time (Vester, 2012).

The goal of this step is to identify and select a set of variables that sufficiently describes the structure and the dynamic of the system like the Val d'Endor watershed area (i) in its current state or (ii) as potential future states (scenarios in 30 years).

In this thesis, system descriptors are interchangeably used with impact variables, sometimes also called impact factors (Scholz and Tietje, 2002). The identification and selection of impact variables is subjective and therefore highly dependent on the researcher's knowledge and expertise. To avoid biases, system analysis is best done by a team representing a variety of perspectives. Studying reports, studies, strategies, planning documents, statistical data, etc. is a first step to understand a system in its structure, functions, and characteristics. Informal and formal talks, field observations, and further methods help complementing system knowledge while brainstorming represent a first step to identify, structure and classify impact variables.

Through a brainstorming a first preliminary set of impact variables that may have an impact on the water provision and retention in the Val d'Endor watershed area were identified. We initially came up with a list of 35 variables; we then iteratively regrouped and reduced, until we had a set of 16 impact variables which we considered sufficient to characterize the system properly. This list was validated by the experts. Each variable was then precisely defined.

This set of descriptors is further processed through a matrix to investigate the system's characteristics and dynamic.

D1.1.4 System dynamic

In this step the impact variables are entered in a matrix to assess direct impacts from one variable to any other. Row and column sums result in activity and passivity values of each variable. Data can be further processed using software to further analyse the dynamic of the system.

Filling in the impact matrix is a critical step to estimate the dynamic of the system at hand. We followed the procedure by Vester (2012) using a four level rating scheme ranging from 0 to 3: 0 = no or very weak direct impact, 1 = weak direct impact, 2 = medium direct impact, 3 = strong direct impact. Vester (2012, p.220) wants the researcher to reflect: "If I change element A, how strongly does element B change as a results of direct influence by A?

If I change A only a little and B then changes a lot, a 3 is called for.

If I need to change A a lot in order to achieve a more or less equally big changes in B, a 2 is entered.

If a marked change in A brings about only a weak change in B, we award a 1.

Where there is no effect at all, a very weak effect, or an effect occurring only after a lengthy delay, we put a 0."

The strategy chosen was the following: first, each of us filled in the matrix separately. After that we compared the results, discussed, and finally changed the rating if needed. Subsequently, four experts were asked to complete the matrix using the same procedure. After carefully reviewing all the ratings we revised the matrix accordingly.

After the matrix was completed, the activitiy and passivity of the impact variables were calculated. The sum of a row represent the activity of a factor. The activity is the impact that one variable has on all the other variables. The sum of a column represent the passivity of a variable. The passivitiy is the impact that all variables have on one specific variable. To illustrate the results of the impact matrix, an activity versus passivity grid was created as well as an impact graph. The former permits to illustrate which factors are active, passive, ambivalant or buffer. Active factors are the ones with a strong influence on other factors, but which are not really influenced by others. Passive factors are the ones which are highly influenced by other factors but which do not really influence other variables. Ambivalent factors are the ones that have a big influence on other variables and other variables have strong influence on them. Buffer factors are the ones that hardly influence other factors and other factors do not influence them. Concerning the impact graph, it actually shows the relations between the variables. As a system graph showing all the impacts is difficult to read, a system graph with only the strong impact was created in order to understand the dynamic of the system. Both graphs allow to better understand the inner dynamic of our system and to highlight the most important variables. The graphs were done with the software SystemQ V10.0 (Copyright 2007-2014, Systaim GmbH, Sep 2016).

D1.1.5 Scenario construction

Each impact variable can have different levels therefore a scenario is a combination of all impact variables and levels.

Based on the impact graph and the activity/passivity graph, we finally selected eleven variables, which best represented the system. Some factors correlated and could therefore be matched, while a few others were dropped off for the purpose of the scenario construction. We decided to reduce the number of variables to make the scenarios simpler and thus clearer for stakeholders. In general, there are two or three levels for each variable, while one level represents the current state (which is described in the current state analysis) and the other level(s) represent a possible development state of the variable compared to the current state. Because of a lack of quantitative data, the levels are determined qualitatively only (for example: increase or decrease compared to the current state). To construct a scenario the selected set of impact variables are combined in different levels. For example, *Water abstraction* can increase, decrease in the future, or stay at the same level as today.

With the support of experts at the Program Coordination Unit (PCU) we identified four different scenarios to be evaluated by stakeholders. For each of these scenarios, a consistency analysis was done. In a consistency analysis, all the combinations of the levels of the impact variables are analysed. Some combinations of levels may be relatively inconsistent. For example, a scenario would not be consistent if we would decide to increase the farming area and in the same time decrease the water abstraction. A matrix is constructed with all levels of impacts factors. Each pair of levels is evaluated with a four level rating: -1 = inconsistency, the levels are inconsistent and cannot occur at the same time; 0 = possibility, the occurrence of one level on the other is possible; 1 = supporting, the occurrence of one level supports the occurrence of the other and 2 = inducing, the occurrence of a level induces the other (inspired from Tietje, 2005; Scholz and Tietje, 2002). The consistency matrix was calculated using the software KD Version 5.1 (Copyright 2003-2013, Systaim GmbH Zürich, January 2013). The consistency analysis was done in order to make sure that the scenarios included no inconsistency.

In a final step, the information from the impact variable and the levels were put into a text form. In other words, short narratives to describe the four scenarios were written (see D2.1.5).

D1.2 Scenario evaluation

The purpose of the scenario evaluation is to identify areas of agreement and disagreement among stakeholder groups affected by or impacting the management of the water catchment territory of the Val d'Endor watershed. Because there is currently no such management system in operation, it is the goal to provide respective information needed to establish such a strategy.

As mentioned in section D1.1, we constructed four future scenarios (see results, section D2.1.5) composed by a set of impact variables. These scenarios were used in order to assess how different stakeholder groups perceived the ecosystem services in Val d'Endor watershed. To investigate people's perception, selected stakeholder groups had to evaluate the desirability and probability of each potential future state (scenario) (Ratcliffe et al., 2004; Pati et al., 2009; Buegl et al., 2012; Meylan et al., 2015). In addition, they went through a criteria based evaluation process to evaluate the scenarios in more detail. We assume that participants took a more intuitive mode when evaluating the overall desirability and probability while they switched into an analytical mode when evaluating the scenarios along a set of criteria. The criteria based evaluations are presented in results' section D2.2.3.

D1.2.1 Criteria selection

Once the scenarios were written (section D2.1.5) different criteria were selected in order to evaluate the different scenarios. This was done by brainstorming and confirmed with experts. These are the basis of the multi-criteria evaluation. They reflect important aspects of the system characteristics and should be measurable with attributes.

D1.2.2 Stakeholders sample

Based on a stakeholder analysis (see section D1.1.1) we identified seven stakeholders groups which are affected by any potential change in the management regime of the water catchment area of Val d'Endor or do impact either catchment area itself or the further management of it. The groups are: PUC, SAA, the environmental group (PCU, MEECC, UNDP[1] and GEF[2]), UniSey (students and lecturers), MLUH, residents and farmers of Val d'Endor. We have between 5 and 11 eleven people per stakeholder groups participating in our survey (Table D1). We hypothesize that these groups vary in their evaluation of the four scenarios. Specifically, we expect a general trend in favour of sustainable scenarios by all stakeholders as they all aim for their own well-being and for the protection of the nature. Nevertheless, it is known that business drives decisions, and we expect farmers to be in favour of increasing farming activities. PUC and SAA will probably have different opinions on water supply management. We expect the environmental group and UniSey to be in favour of complete protection of watershed, with a stronger legal context and law enforcement. In total we included 58 participants of whom we know the age, work position and place of residence. We did not use that information for our analysis as the sample size per stakeholders group is not big enough to divide them into smaller categories (age-wise or location-wise). For confidential questions, these data are available only on request.

Table D1: Number of people per stakeholder groups participating in the survey.

Stakeholder groups	Number of people
Environmental group	8
PUC	8
SAA	11
UniSey	7
MLUH	5
Residents	9
Farmers	10

D1.2.3 Questionnaire

The questionnaire is structured as follows: a first part provides information about this thesis project, its purpose, the evaluation procedure, the impact variables we used for the scenario construction and a list of evaluation criteria. A second part includes the scenarios and the measurement tool, i.e. (1) a form to evaluate the importance of criteria; (2) a form to evaluate the current state along the five criteria; (3) the description of the four scenarios; (4) different scales in order to evaluate the four scenarios; and (5) a few open questions at the end of the questionnaire. The complete questionnaire can be found in the APPENDIX G1.

To evaluate desirability and probability of the scenarios, we used scales ranging from 0 to 10 (0=not at all desirable/probable and 10=highly desirable/probable). Concerning the criteria based evaluation, the evaluation of the performance of the criteria in the current state, we used a scale ranging from 1 to 7 (1=very bad and 7=very good). For the perception of the criteria in the different scenarios another scale was used, varying from -3 to +3, i.e. -3=much less satisfied; -2=less satisfied; -1=slightly less satisfied; 0= same as current state; +1=slightly more satisfied; +2=more satisfied; and +3= much more satisfied. Participants evaluated each criterion in each scenario following this question: “Am I more / less satisfied with this scenario compared to its current status with regard to this criterion?” For example, a zero (0) would mean, that respondents rate this scenario in the respective criterion neither better nor worse than the current state.

[1] The United Nations Development Program (UNDP) is the UN's global development network, advocating for change and connecting countries to knowledge, experience and resources to help people build a better life.

[2] The Global Environment Facility (GEF) provides grants to developing countries, and countries with economies in transition for projects within the three focal areas; Biodiversity, Climate Change and Land Degradation.

D1.2.4 Data collection procedure

In general, we conducted face-to-face interviews except for MLUH, the environmental group and UniSey, to whom the questionnaires were handed out and collected at a later stage because of time constraint and impossibility to gather all participants of each group at once.

We first introduced participants to the task. People then worked independently on the questionnaire, and we were available to answer questions if needed. It took approximately an hour to complete the questionnaire.

The procedure in more detail: we explained background and goals of the overall study as well as of the evaluation. In a next step, the four scenarios were presented and all the different steps to complete the questionnaire were described precisely. As a first step, participants had to rate how important to them each of the criteria was. In a second step, they had to evaluate the current state along the five criteria (this step was to set the performance of the five criteria in the current state, it states the baseline for the criteria based evaluation of the scenarios). As a next step they had to answer how desirable and probable each scenario was which then was followed by the criteria based evaluation. The procedure was completed after answering some socio-demographic questions. These questions were chosen to have a better in depth vision of participants' perceptions on the watersheds and their concerns on water availability and quality.

D1.2.5 Data analysis

We analysed the data using the statistical program Prism 7 (version 7.00; mars 31, 2016). Descriptive statistics include, in general, means and standard deviation values only. For testing differences between scenarios or between groups we performed one-way ANOVAs which were followed by Tukey's multiple comparison post-hoc tests. The latter assumes normally distributed data and homogeneity of variance.

D2 Results

This section presents first, the results of the system analysis and scenario development which include the characterization of ecosystem services and users, current state, system descriptors, system dynamic and the construction of scenarios. Secondly, the results of the scenario evaluation are presented and include the selection of criteria, the overall evaluation regarding desirability and probability and the criteria-based evaluation.

D2.1 System analysis and scenario development

D2.1.1 Ecosystem services and users

This section present the ecosystem services identified in Val d'Endor watershed and the users connected to them.

1. Ecosystem services

Table D2 summarizes the different ecosystem services identified in the Val d'Endor watershed. We have to note here that the focus is on hydrological services and in particular freshwater provision (quantity and availability) and retention although there might be many others, however, beyond the scope of this study.

There are three general services in Val d'Endor watershed: hydrological services, food and forest. These services can be influenced by different factors. For example, water management, climate, type and extent of forest, etc. influence the hydrological services such as water for agriculture and water for household purposes. In the catchment, there are a lot of fruit trees that can be harvested. Of course, it is influenced by its accessibility. The forest in Val d'Endor is usually dense, there is no trail and the terrain is steep. The forest itself is also a service. Indeed, the forest can deliver services such as timber, and medicinal plants.

Thus, the composition of the forest can be influenced by the timber activities, and by harvesting medicinal plants.

Table D2: Characterization of ecosystem services in Val d'Endor watershed.

Ecosystem services of Val d’Endor watershed	Factors influencing the eco-services
Hydrological services: 1. Drinkable water 2. Water for agriculture 3. Water for households 4. Water for recreation 5. Mitigation of flooding 6. Prevention of erosion 7. Retention of water	1. Type of forest 2. Extent of forest 3. Climate (rainfall pattern, temperature) 4. Location 5. Water management 6. Pollution of water (waste dumping, fertilizers, etc.) 7. Agriculture (plant cover, soil, infrastructure, etc.) 8. Housing 9. Topography
Food	1. Accessibility (roads, ways, etc.) 2. Diseases 3. Time of the year 4. Soil 5. Fertilizers 6. Animals
Forest	1. Timber activities 2. Recreational activities 3. Medicinal use of plants

2. Users – Stakeholder analysis

In total, we identified 19 stakeholders. Note that a stakeholder can either be an individual or an institution. In the Table D3 below, one can see the description of the eight stakeholders that participated in the scenario evaluation, meaning SAA, MLUH, PUC, PCU MEECC, UniSey, farmers and residents of Val d’Endor. In Table D3 one can see the stakeholders’ main focus, main aims and respective link to the Val d’Endor watershed. It is obvious that each stakeholder has different interests towards the watershed. Indeed, SAA and MLUH are both responsible for land allocation; the former only for agriculture, the latter for housing and other purposes. PUC and SAA both have water barrages and provide freshwater; the former for housing purposes and the latter for agricultural purposes (irrigation). Farmers and residents use water provided by SAA, PUC or abstract it themselves directly from the river (for more detail see D2.1.2). MEECC sets environmental regulations and is in charge of enforcing them. In addition, PCU which is under the division of the MEECC aims to rehabilitate the Val d’Endor watershed (EBA project). The UniSey collaborates with the EBA project team and carries out study on water quality and water flow.

The remaining 11 stakeholders are also important and are presented in APPENDIX G2 (Table G14). They did not participate in the scenario evaluation, because some of them are really closely connected to one of the eight stakeholders (Figure D1) or because they can influence the water catchment to a lesser extent. However, the Public Health Authority should have been included in the scenario evaluation as it plays a major role in terms of freshwater quality. Unfortunately, it was not possible to find a minimal number of people willing to participate to the scenario evaluation.

Table D3: Stakeholders that participated to the scenario evaluation.

Stakeholders	General Focus	Aim(s)	Link to the Val d'Endor watershed
Farmers of Val d'Endor	- Agriculture	To make a living with food production	- Land use - Water use
GOS[3]/UNDP/GEF Programme Coordination Unit (PCU)	- Environment	To coordinate all the different UNDP / GEF environmental projects and ensures independent and effective facilitation between different stakeholders	- EbA project - Protection of watershed
Ministry of Environment, Energy and Climate Change (MEECC)	- Environment	To be responsible for all environmental issues in terms of policies and regulations	- In charge of the PCU - Sets environmental regulations to protect the watershed - Law enforcement
Ministry of Land Use and Housing (MLUH)	- Housing - Land use	To facilitate the national socio-economic development through sustainable and efficient use	- Land allocation and housing
Public Utilities Corporation (PUC)	- Electricity services - Water services - Sewage services	To provide a reliable supply of fresh water	- Provide potable water for household purposes
Residents of Val d'Endor	- Living	To have a place to live	- Land use - Water use
Seychelles Agricultural Agency (SAA)	- Agriculture - Land use	To achieve food security and develop national agricultural sector while conserving the environment and quality of life	- Provide water for irrigation - Allocate agricultural land - Precious help for famers
University of Seychelles (UniSey)	- Environment - Knowledge production - Education	To provide (environmental) knowledge to the new generation	- Collaboration with EbA project - Studies on water quality

Figure D1 gives an overview of the relationships between the stakeholders. It also shows which stakeholder is the most interconnected (has the most relations) in our system. In our focus on water supply and retention, one can observe that the MEECC is a key stakeholder. It is linked to six other stakeholders. It is in charge of PCU, LWMA (Landscape and Waste Management Agency) and MET (Seychelles Meteorological Services). It manages PUC and collaborates with Ministry of Health. The Ministry of Health and the District Administration (DA) arrives second with four links. Ministry of Health is in charge of the Public Health Authority (PHA) which is in charge of controlling water quality and make sure safe potable water is distributed to the public. It collaborates with PUC and MEECC. DA is under the aegis of the five Ministries shown below. The DA is important, as its role is to serve as an interface between the community in the affairs of the district and promoting access to public services at the local level.

[3] Government of Seychelles

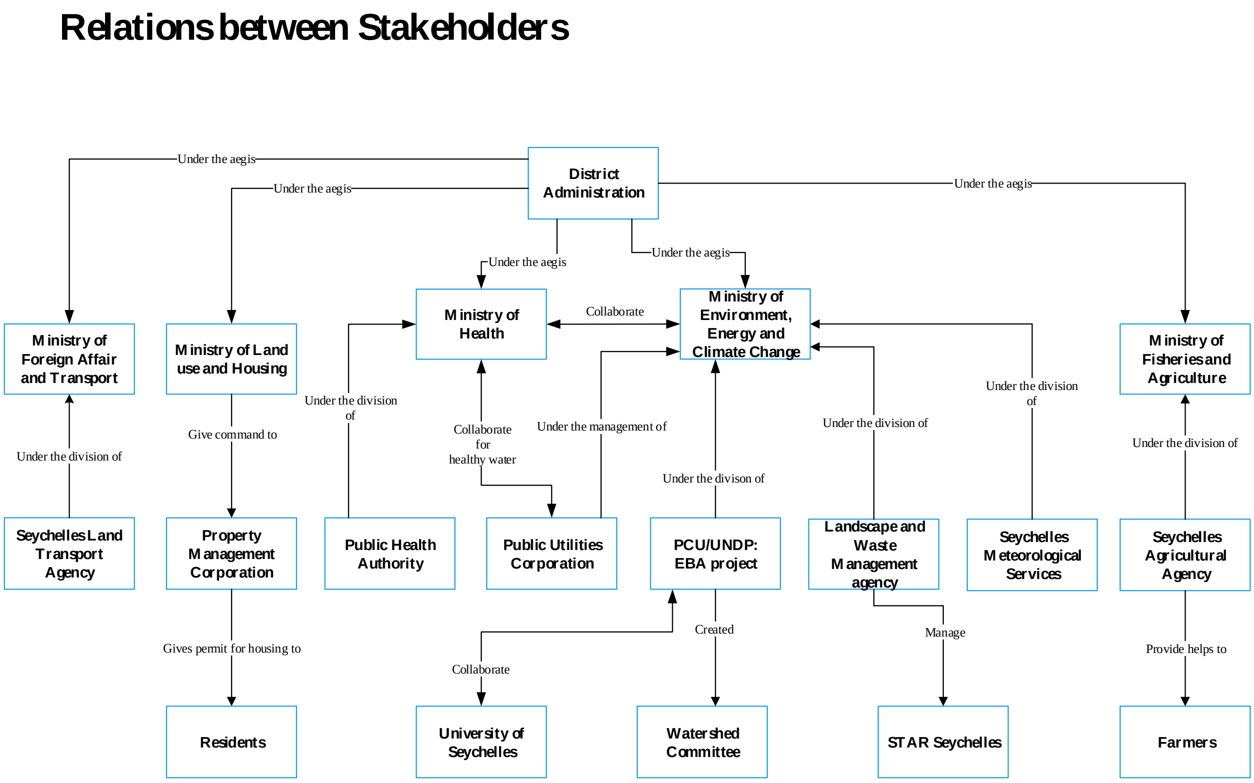


Figure D1: Relationships among the 19 stakeholders.

D2.1.2 Current state

This section describes the current state situation. Structural elements and land use practices were investigated to characterize and qualify the catchment area. This means all the elements in the watershed that have a direct or indirect impact (see methods, D1.1.2) on the hydrological services of the watershed are described in more detail.

Figure D3 represents the current state of the watershed. First, the boundary of the water catchment is represented with a bold red line. The blue line represents the Baie Lazare River. Different land uses can be identified within this watershed: few buffer zones (light orange), one zone of low density residential (light pink), some medium density residential (light purple), some medium density residential and agriculture (pink), a zone of high density residential (dark purple), one very small commercial and residences zone (bright light green), one small medium residential and tourism (light blue), a lot of crop production areas (yellow with dashed green lines), a lot of forest reserves (faded green), one public building (bright orange), one coastal wetland (dark green) and upland wetland (bright blue). There are five bins sites within the watershed, two SAA barrages, three PUC reservoirs, 21 private water abstraction point, two PUC pump stations, and two PUC treatment plants. One can also see the PUC pipes system. The existing agricultural plots are delimited in orange, the cadastral are represented in grey and finally the five and ten meter contour lines show the relief of the watershed. It can be observed that most of the houses are near the river or near its tributaries. Private abstraction points are close to rivers (freshwater abstraction) or in the middle of the forest (groundwater abstraction).

The Val d'Endor watershed is characterized as the biggest agricultural area on Mahe (see below agriculture). It is a rural area with a low density of housing. Farming activities and housing are the only source of water consumption as there is no large industrial company. Freshwater is taken directly from the

Baie Lazare River by PUC, SAA, residents or farmers. For this reason, housing has an impact on water supply in general (see below housing). Furthermore, residents produce household wastes which can pollute the watershed if they are not taken care properly by waste companies (see housing and waste management). In addition, residents produce sewage (see water management) which are stored in septic tanks. The entire water management for residents is taken care by PUC. SAA provides water to farmers for irrigation. Farmers or residents also extract water directly from the river and drill wells for their own use. There is also agricultural contamination such as animals' excrements, dead animals, pesticides and fertilizers (see agriculture). Farmers use agricultural lands for their crops or livestock. Housing and farming decrease the area of the forest. This increases surface runoff and therefore decrease the water retention in general. There are several acts regulating environment protection, water supply, water quality etc. but the law is poorly enforced. The current state of the Val d'Endor watershed is more precisely described below based on the factor influencing the hydrological services from Table D2.

1. Topography

The watershed is delimited by natural boundaries, i.e. ridge lines or watershed lines which have altitudes between 221 and 378m. Three hills are surrounding the watershed: Maravi (number 1, Figure D2) at 221m on the south east, Mont Parnel (number 2, Figure D2) at 378m on the south west and Le Desert (number 3, Figure D2) at 330m in the north west. Approximately 60% of the watershed is composed of forest, while 30% goes to farming activities and the rest is residential area (Figure D3).

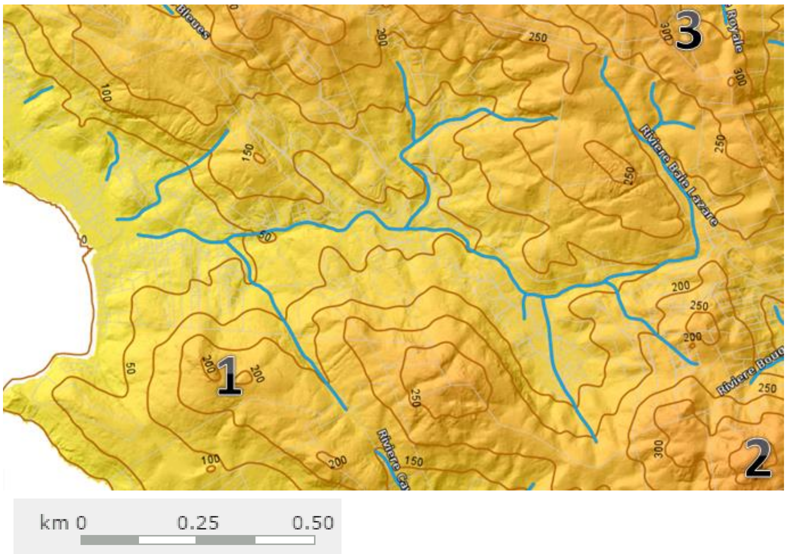


Figure D2: Relief and 50m contour line around the Baie Lazare River (source: https://www.webgis.gov.sc/)

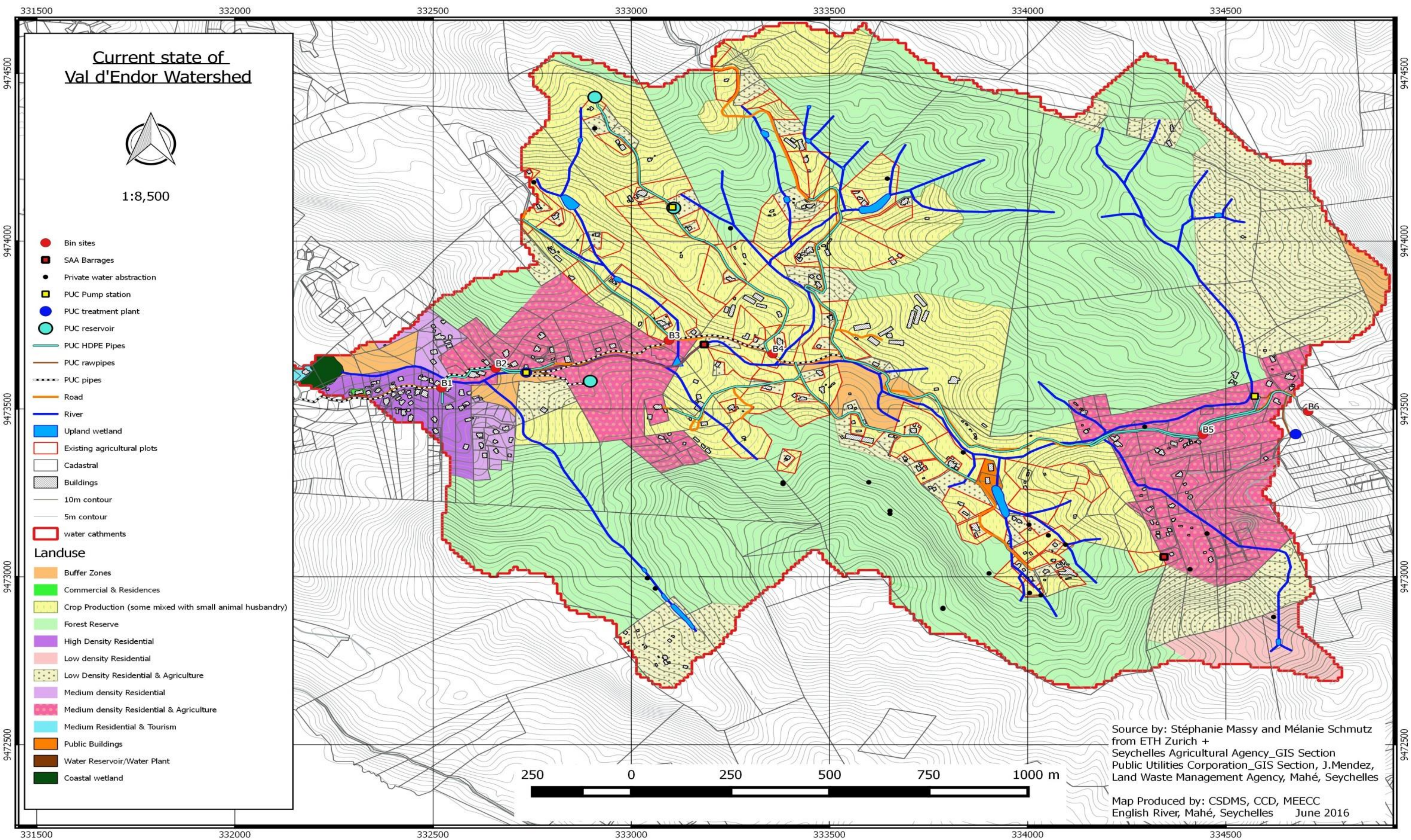


Figure D3: Map of the current state of the Val d'Endor watershed.

Note: On this map are described: bins sites, SAA barrages, private water abstraction points, PUC pump stations, PUC treatment plants, PUC reservoirs, PUC pipes system, roads, Baie Lazare River, different wetlands, agricultural plots, cadastral, contour lines and the land use.

2. Land allocation

There are 427 parcels in the Val d'Endor watershed out of which 130 parcels are state land and 297 parcels are privately owned. This means that 30.4% of the parcels are state lands. These 130 parcels represent 1.37 km^2 meaning that 38.1% of the area is owned by the government (Figure D4).

The management section of the MLUH manages the allocation of lands. SAA is also responsible for allocating lands but exclusively agricultural lands to farmers.

There are 3 acts[4] and 1 policy (last of the list below) concerning land allocation which can ultimately have an influence on Val d'Endor watershed primary function:

Acquisition of Land in the Public Interest Act (cap 1a) – " sets out in the Schedule forms, which are prescribed for the purposes of the provisions of the Acquisition of Land in the Public Interest Act respectively specified in each such form"

Land Registration Act (cap 107) – "provides rules for the registration of rights in land in the Seychelles."

Land Settlement (Perpetual Leases of State Land) Act (cap 108) – "provides for the grant by the Government of perpetual leases, i.e. leases of State land granted for the purposes of land settlement, which shall endure in perpetuity unless they lapse or are terminated or surrendered."

Seychelles Strategic Land Use and Development Plan (2015) – "sets out the long term spatial planning framework for the country up to 2040."

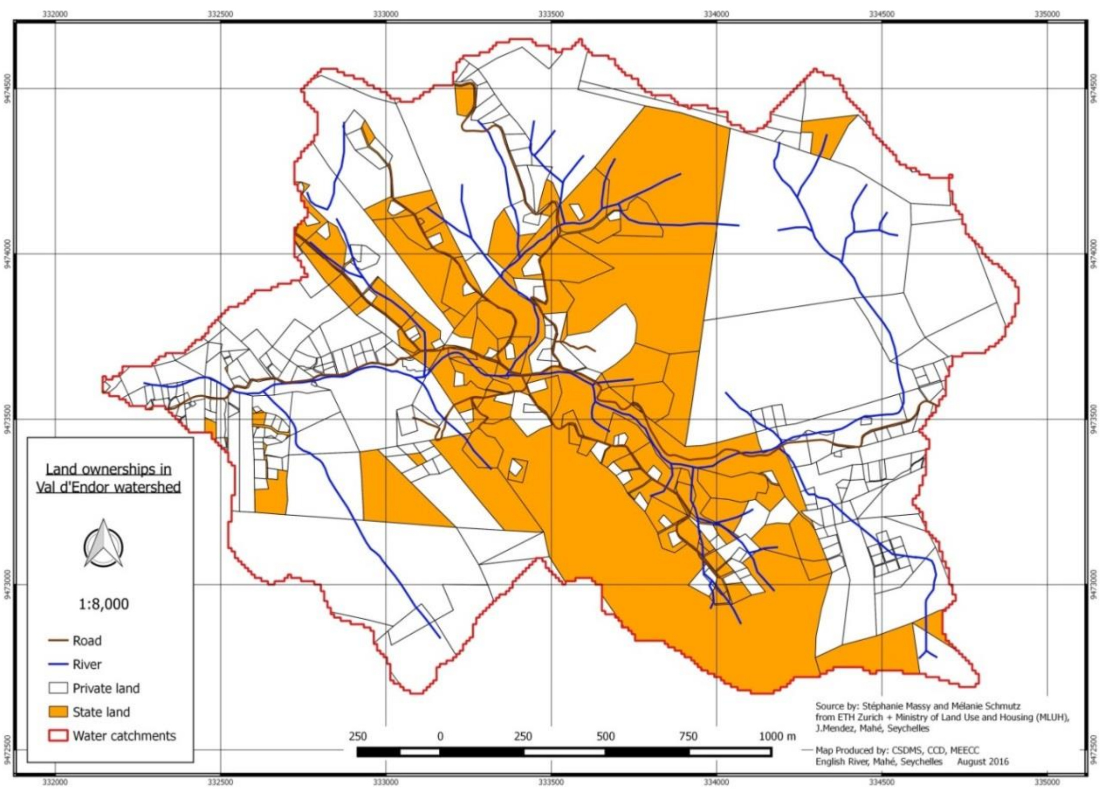


Figure D4: Land ownerships of the Val d'Endor watershed.

[4] All acts can be found on: http://www.seylii.org/

3. Housing

As there is no statistics records on the number of building in Val d'Endor watershed, a visual count was performed (Figure D3). We can assess that there are approximately 330 buildings.

In terms of water consumption, people use water for household purpose such as drinking, cooking, washing and sewage. The average per capita consumption of water on Mahe is about 160 liters a day (for more detail see water management below).

Concerning the production of solid wastes, the approximate waste tonnage per capita per annum as recorded for all 3 main islands of Seychelles is 0.78 tons. Household wastes are displaced in green bins (see waste management below) (Interviewee 3)[5]. Unfortunately, littering is quite common in Seychelles, it is however not possible to quantify it. We have observed lots of littering in cities, rural areas and in the forest. Remote places such as forests are much more impacted by littering as there is no official company in charge of cleaning those areas. In Val d'Endor, sewage (liquid wastes) are disposed in septic tanks and soak away pits. Private operators collect the sewage when the septic tank is full (see water management).

4. Agriculture

Baie lazare is the biggest agriculture area on Mahe. Not in terms of size of farms but in terms of area. Agricultural land covers about 1/3 of the watershed. There are 95 farmers in Val d'Endor (Interviewee 2).

Baie Lazare River freshwater is used for irrigation of crops. There is no meter in the Val d'Endor watershed to estimate the amount of water used daily by farmers. Different type of irrigation systems like overhead sprinkle, mini-sprinkle, drip and rainfed irrigation are used (Interviewee 4). SAA provides water for irrigation to the majority of farmers (see water management below). 20-25% of farmers in Val d'Endor abstract water directly from the river but they have to get permission from PUC. However some of them abstract water illegally from the river (Interviewee 2).

As for pest control, farmers are using mainly chemicals (synthetic and bio-pesticide). For some pests, they are using traps and pheromone or sticky traps. For fertilizers, they use both synthetic and organic products as well as chicken and cattle manure. For weed control, they are using mainly herbicides as there is a shortage of labor (Interviewee 4). Pesticides and fertilizers are sold at SAA stores which are found in every agricultural area on Mahe (one SAA shop is found in Val d'Endor). SAA control the importation and the types of pesticides. SAA trains farmers on how to use pesticides, and each farmer has to pass a test to apply pesticides properly. Farmers follow the directions on the products to use them properly. They will probably not apply more than recommended as it is very expensive. Furthermore, SAA recommends to farmers to use pesticides and fertilizers rationally (Interviewee 2). The use of pesticides and fertilizers can ultimately create agricultural contamination to the water.

There is also another kind of contamination by dead animals and faeces. Farmers must eliminate dead animal in a proper way, meaning burning them to avoid any kind of disease contamination. They must also dispose faeces in tanks and must get rid of them properly (Interviewee 2).

As for the agricultural practices, most farmers are cultivating on mountainous red soil with acidic pH and the topography is mainly gentle slope to steep slope. Most of the land is terraced. There are pockets of alluvial soil and marshy areas. The farmers are growing mainly root crops (cassava, sweet potato and yam), fruits like banana, pawpaw, citrus, avocado, and pineapple. Some farmers are still doing the tillage manually with a hoe while others are using a Rotorvator™ (Interviewee 4).

[5] For confidential reason, all interviewees remain anonymous. Names are known by the authors only.

There are 5 acts concerning agriculture that can potentially have an influence on the Val d'Endor watershed primary function:

Agriculture Act (cap 5) – "provides for the conservation of the soil and fertility and for the eradication of bracken fern and other prescribed vegetation."

Control of Slaughtering of Cattle Act (cap 48) – "places restrictions on the slaughtering of cows, heifers and heifer calves and provides for some other matters relative to slaughtering of cattle."

Seychelles Agricultural Agency Act (2009/4) – "establishes the Seychelles Agricultural Agency as a body corporate, defines its powers and functions and provides for its administration and functioning. "

Pesticides Control Act (cap 164A) – "regulates the manufacture, distribution, use, storage and disposal of pesticides."

Pig Production (Control) Act (cap 170) – "provides for the public control of the reproduction and fattening of pigs."

5. <u>Waste management</u>

Here are described only household wastes and green wastes which are the two major wastes of the Val d'Endor watershed. People in household do not separate their wastes, 100% of household wastes are disposed in landfill. Recycling exists but only for large companies: scrap metal, PET bottles and aluminum, all of them are exported. There were 71'000 tons of wastes last year (2015) for 91'000 people in the Seychelles. Household wastes represent 45% of these 71'000 tons of wastes (Interviewee 3). Residents usually burn green wastes outside.

The municipality wastes (household wastes) are deposited in green bins along the main roads and country roads. There are five green bin sites in Val d'Endor (Figure D3). These should be collected on a daily basis by private contractors (STAR for Mahe). In Val d'Endor, we have observed that green bins are not always collected daily but sometimes every 2-3 days. The bins are displaced depending on the topography, density and importance of the area and also depending on tourist density. One bin site contains on average four bins and serves 20 houses (Interviewee 3). There are no clear regulations for the location of the bins (although it is not allowed to place it on private property). Bins are located on state land and, on areas which are accessible by collecting trucks. The location of bins is determined by the DA (Interviewee 3).

After collection, all domestic wastes from Val d'Endor are disposed on a landfill in Providence. There is no waste treatment for now. But it is a goal for LWMA to build waste treatment plants in Seychelles (Interviewee 3).

There are 2 policies concerning waste management that can potentially have an influence on the Val d'Endor watershed:

Solid waste master plan (2003-2010)

Landscape and waste management agency - Strategic Plan (2016 – 2020)

6. <u>Water management</u>

Water management can be described in four categories: water abstraction, water treatment, water distribution and sewage collection. Water supply comes essentially from rivers, groundwater and desalination plants (SNCCS, 2011). In the granitic islands of Seychelles, there is an annual rainfall of 2200 mm per year (SSDS, Vol.2). This is sufficient for providing people with adequate water supply

(SSDS, Vol.2). On the other hand, retention or capture of water is inadequate (SSDS, Vol.2). Mahe Island only has a retention capacity of 2 months and the water consumption per capita is of 160 L/day (SSDS, Vol.2). Furthermore, the aquifers are small and shallow (maximum 20 meters in thickness) (Shahin, 2002). The permeability is around 10 m/d and the storativity is around 0.10 (Shahin, 2002).

Water is in most cases abstracted by PUC. However, there are some households that are abstracting water directly from rivers for their own consumption. They pay PUC a minimal fee for a license for this activity. SAA is also abstracting water for irrigation purposes only (Interviewee 5). There is also illegal abstraction of water by residents and farmers who take water directly from the river without requesting a license from PUC. Moreover, some farmers abstract groundwater with wells. There are 21 water abstractions points from residents in Val d'Endor (Figure D3) (Interviewee 6). PUC can abstract 800 m^3 per day of water from Baie Lazare River (Interviewee 7). PUC abstracts water from small barrages, then water is moved to the raw water storage tank through pipes. From there it goes to the treatment plant, where it is filtered and chlorinated, before being distributed to households (Interviewee 5). There are three PUC barrages (called reservoirs) in Val d'Endor and two SAA barrages (Figure D3).

Before the water is distributed, it first has to be treated. There are two water treatment plants in Val d'Endor (Figure D3). One of them is just outside of the watershed area. After this step, the water is distributed to houses through pipes. The majority of houses in Val d'Endor have private water basins to store the water in case of water shortage during dry season. Farmers also have private tanks for the same reason.

As previously mentioned, liquid waste goes into septic tanks and soak away pits in Val d'Endor. There is a rule that soak aways should be located at least 16m away from any water bodies (PUC ACT, Part 3, 19e). PUC also does not allow the construction of any septic tanks above the water catchments which can compromise the quality of water that is abstracted (Interviewee 5). Nevertheless, in Val d'Endor, we could observe housing or farming above at least one of the barrages. These were constructed before the establishment of the act.

There are 1 act and 2 policies concerning water management that can potentially have an influence on the Val d'Endor watershed primary function:

Public Utilities Corporation Act (Cap 196) – "regulates the use of water throughout the country as well as sewage disposal systems both public and private."

Sanitation master plan (2010-2025) **-** will contain the main strategy for sanitation services in the Republic of Seychelles.

Seychelles water supply development plan (2008-2030) **-** "to ensure availability of adequate and affordable water up to the year 2030 to meet needs of the population, industry and tourism."

7. <u>Climate</u>

The climate in Seychelles is influenced by different factors such as (a) the shifts in monsoonal winds, (b) the position and intensity of the South Indian Ocean tropical anticyclone, (c) the ocean currents of the equatorial Indian Ocean, and (d) the temperature at the sea surface (Payet, 2007). Shifts in rainfall patterns and in temperature have been observed and are described below. There is no specific data on the Val d'Endor watershed. But we will talk about climate on Mahe in general.

Rainfall pattern:

Current trends: there is an annual rainfall of 2,200 mm/year (SSDS, Vol.2). From 1972 to 2006, an increase of 13.7 mm per year has been observed on Mahe Island (SNCCS, 2011).

Future trends: According to Chang-Seng (2007), in 2025 the range in percentage change in annual rainfall is from -2.4% to +5%; in 2050 from -4.8% to +8.5%; and in 2100 from -8.6% to +16.3%. The conclusions are that during the north-west monsoon (December to February) rainfall will likely increase and that over June to August period it is unlikely that it will rain at all.

Temperature:

Current trends: a warming trend of 0.25°C has been observed from 1972 to 1997 (Payet, 2006). A more recent work on rising temperatures in Seychelles estimated a 0.33°C increase during the past 34 years especially over December-February months (Chang-Seng, 2007).

Future trends: the range of annual temperature rise in 2025 is +0.4°C to +0.7°C, in 2050 from +0.7°C to +1.3°C; and in 2100 from +1.5°C to +2.5°C (SNCCS, 2011).

There is 1 policy concerning climate that can potentially have an influence on the Val d'Endor watershed:

Seychelles National Climate Change Strategy - "minimise the impacts of climate change through concerted and proactive action at all levels of society"

8. Forest

Forest in the Val d'Endor watershed is very important as it plays a significant role in the hydrological cycle of the watershed. The average yearly evapotranspiration on Mahe is 4.6 mm/day (Interviewee 8). Refer to sections on vegetation analysis and assessment (C2.1 and C2.2) for further information on vegetation such as species diversity, groundcover, rejuvenation rate, etc.

There are 4 acts concerning forest that can potentially have an influence on the Val d'Endor watershed:

Protected Areas Act (cap 185)

Breadfruit and Other Trees (Protection) Act (cap 18) – "prohibits the destroying or causing to destroy any tree specified in the Schedule without a written permission obtained from the Chief Agricultural Officer"

Forest Reserves Act (cap 84) – "grants powers to the Minister to constitute Forest Reserves and lays down rules relative to acts in or in relation with such reserve."

National Parks and Nature conservancy act (cap 141)

9. Connectivity

Connectivity refers to the location and number of roads in Val d'Endor (Figure D5). There is one country road that goes through the island from west to east (from Bougainville to Baie Lazare). Then, there are several dead-end smaller roads that lead to the different housing area of the watershed. Another smaller road starts halfway of the country road and leads to the main road between Baie Lazare and Anse a la Mouche.

Figure D5: Location of roads (in grey) in the Val d'Endor watershed.
Note: Baie Lazare River is in blue (source: https://www.webgis.gov.sc/).

10. Environmental protection

The Watershed is not protected per se: the trees are protected but the forest is not. There are strict measures for cutting trees and only the national park on Mahe is under strict regulations.

There are 2 acts and 1 policy concerning environmental protection that can potentially have an influence on the Val d’Endor watershed:

Environment Protection Act (Cap 71) – “provides for the protection, improvement and preservation of the environment and for the prevention, control and abatement of environmental pollution.”

State Land and River Reserves Act (cap 228) – “makes provision for the management and alienation of State land, for the appointment of forest rangers and for the protection of State lands and River Reserves.”

Seychelles Sustainable Development Strategy (2012-2020) - “sets the plan for the implementation of priorities for government, the private sector and the public at large with the final goal of improving sustainable development management in the Seychelles “

11. Health protection

The standard for the quality of drinking water is found in the Public Health Act in Schedule 1: “STANDARD FOR THE QUALITY OF DRINKING WATER”. It focuses on the bacteriological contents, nitrate levels, potassium levels, and indicator species such as fish and freshwater plants (Interviewee 9).

Public Health Act (Cap 189) – “provides competences to Ministry of Health in respect to chemical examination and bacteriological examination of any supply or source of supply of water which is or may be used for drinking or domestic purposes.”

12. Law enforcement

Despite strong legislations, the law is poorly enforced in Seychelles. Only ministries can enforce the law. Law enforcement is not as effective as desired. Within the environmental ministry there are 8 people working on law enforcement and unfortunately they cannot control everything. They rely on the public to report violations. Denouncement is not very popular within the population and when a violation is reported, there is usually no evidence left to prove the action or to prove who is responsible for it. If someone breaks a law defined in an act, the consequences can be really severe, but if someone breaks a regulation, the punishment will usually be lighter (Interviewee 10).

D2.1.3 System descriptors

In this section, we present the descriptors that feed into scenario construction (section D2.1.5). Descriptors or impact variables can be seen as physical, biological, chemical or social stressors, which potentially trigger changes in the system. The following selected impact factors are thought to sufficiently represent the current system (water retention and provision system) of the Val d'Endor watershed area and which have the potential to characterize potential future states (Table D4): (1) *Irrigation*, (2) *Agricultural by-products*, (3) *Water abstraction*, (4) *Water storage infrastructure*, (5) *Water consumption* , (6) *Sanitation system*, (7) *Waste dumping*, (8) *Road infrastructure*, (9) *Housing*, (10) *Farming area*, (11) *Legal context*, (12) *Law enforcement*, (13) *Extent of forest*, (14) *Forest structure*, (15) *Weather*, and (16) *Topography*.

Table D4: List and definition of the impact variables.

Impact variables	Definition
Irrigation	This variable refers to the amount of water and the respective system used for irrigation purposes in the agricultural sector.
Agricultural by-products	This variable refers to runoff and leaching of pesticides and fertilizers, erosion and dust from cultivation, improper disposal of animals' faeces and dead animals.
Water abstraction	This variable represents where, how and how much water is diverted in Val d'Endor, i.e. water diverted by gravity into pipes from small barrages situated within the Baie Lazare River.
Water storage infrastructure	This variable refers to the number and the type of infrastructure used for water storage such as PUC barrages, Seychelles Agricultural Agency (SAA) barrage, barrages constructed by residents and farmers, wells, distribution tanks (PUC) and private water tanks (farmers and residents).
Water consumption	This variable represents the amount of water used by inhabitants in Val d'Endor for domestic use.
Sanitation system	This variable refers to the kind of sanitation system present in the Val d'Endor water catchment (i.e. septic tanks and soak away pits) and overflowing of sewage.
Waste dumping	This variable represents littering, for example due to improper bin management system or illegal dumping.
Road infrastructure	This variable refers to the location and number of roads present in Val d'Endor watershed. It also takes into account the surface runoff created because of roads.
Housing	This variable refers to the number of houses and buildings, and the total area for housing in Val d'Endor.
Farming area	This variable refers to the total area used for agricultural purposes in Val d'Endor. It refers as well to the distribution of agricultural land in Val d'Endor.
Legal context	This variable refers to the policies, legislations and regulations regarding protection of rivers, forest and land in catchment areas.
Law enforcement	This variable refers to the discovery, identification and punishment of people who trespass the laws and regulations.
Extent of Forest	This variable represents the total area of forest in Val d'Endor watershed.
Forest structure	This variable refers to the diversity of trees, ground cover, roots structure and depth, trees structure, and canopy cover.
Weather	This external variable refers to the daily rainfall as well as the mean daily temperature on Val d'Endor.
Topography	This variable takes into account the landscape structure and the relief. The landscape structure is described as natural features (forest, meadow, open land, river bank and type of soil).

D2.1.4 System dynamic

In this section we present the system grid and graph to show how the system is structured and what kind of dynamic it has. Both depictions represent the outcome of the impact matrix assessment of all the 16 impact variables but in different ways. In the impact matrix we assessed the direct influences of one to another factor. From this matrix results an activity and passivity value for each impact factor. The impact matrix can be found in the APPENDIX G2 (Table G15).

The system grid (Figure D6) shows the activity and the passivity of each impact factors. We distinguish four quadrants each representing a specific characteristic of the impact variables called passive, active, ambivalent and buffer. These four quadrants are separated by the average of the activity/passivity scores. Active means here that the factor has a major direct influence on a number of other factors. By changing a bit those factors, the system (i.e. the other impact factors) can change drastically. Passive means that the factor is highly impacted by the other factors but the variation of the passive factor will not impact a lot on the system. Ambivalent means that the factor is at the same time active and passive. The impacts of these factors on other impact factors are actually hard to predict. Finally, buffer means that the factor is nor impacting a lot the other factors nor being highly impacted by the other factors. Above each factor, there are two numbers which represent the activity (on the left) and passivity scores (on the right). Only two factors are active: *Weather* and *Topography*, although the latter is almost ambivalent. *Legal context*, *Housing*, *Farming area*, *Water storage infrastructure* and *Water abstraction* are ambivalent. The three former are nevertheless more active than passive, while the two others are more passive than active. Only two factors are passive: *Irrigation* and *Forest structure*. Finally, all the other variables are buffer factors. *Law enforcement* is however very close to the active quadrant.

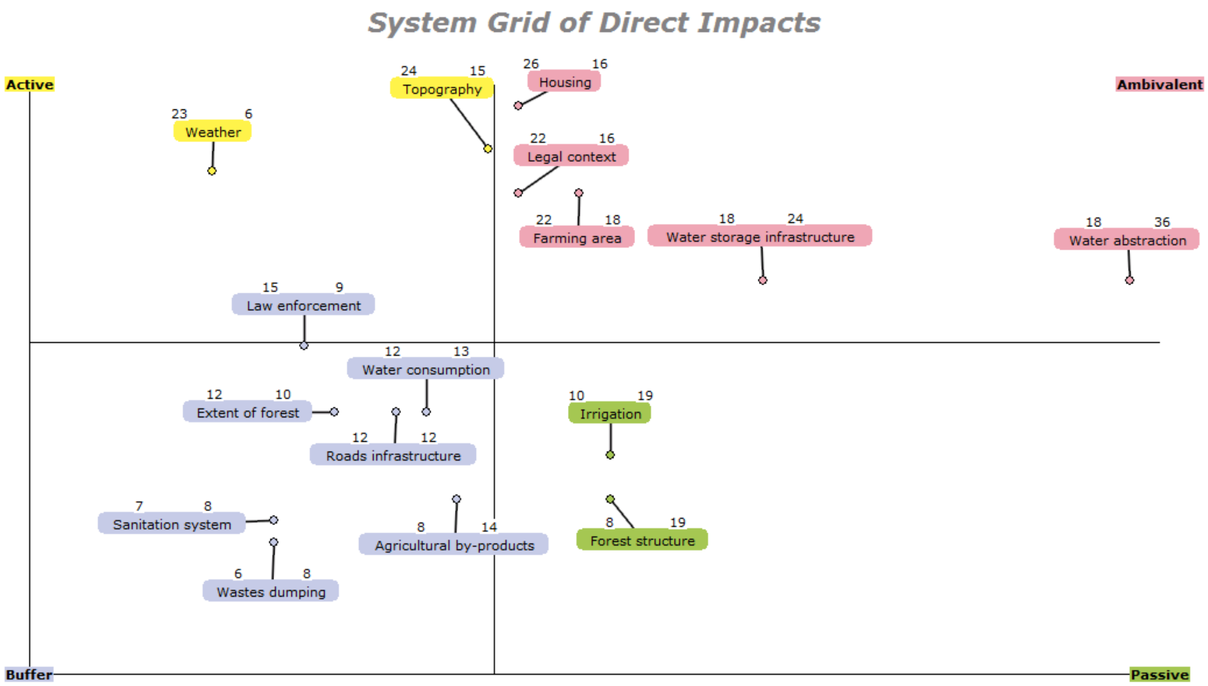


Figure D6: System grid of the impact variables.
Note: The quadrant on the upper left side contains the active variables. The quadrant on the upper right side contains the ambivalent variables. The quadrant on the lower left side contains the buffer variables and the quadrant on the lower right side contains the passive variables. The mean passivity and activity (15.2) divide the grid into four quadrants.

The system graph (Figure D7) depicts all the impact factors and their strong direct impact on one another. Most of the factors are highly interconnected, except for 6 of them (*Roads infrastructure*, *Legal context*, *Sanitation system*, *Waste dumping*, *Forest Structure*, and *Extent of forest*).

Water abstraction is the one being the most strongly impacted by other variables (9 variables) followed by *Irrigation* (5 variables), *Water storage infrastructure* (4 variables), *Agricultural by-products* and *Water consumption* (both 3 variables), and *Farming area* (2 variables). The remaining variables are either being strongly impacted by 1 variable (*Sanitation system*, *Roads infrastructure*, *Waste dumping*, *Topography*, and *Forest structure*) or not being impacted by any variables at all (*Legal context*, *Law enforcement*, *Weather*, and *Extent of forest*).

Housing has the most direct strong impact on other variables (on 5 other variables). It is followed by *Water storage infrastructure*, *Weather* and *Topography* which strongly impact 4 other variables, then *Water abstraction*, *Law enforcement* and *Farming area* strongly impact three other variables, *Irrigation* two other variables and finally *Extent of forest* and *Legal context* one variable.

As previously seen, *Water abstraction* is the most interlinked variable and the most impacted by other variables. These are *Topography*, *Farming area*, *Law enforcement*, *Agricultural by-products*, *Weather*, and *Housing*. In addition, *Water storage infrastructure*, *Water consumption* and *Irrigation* also impact *Water abstraction* which in turn has as well an impact on them. Thus, by changing slightly one of these 9 variables, for example *Housing*, *Water abstraction* will strongly be affected. It will then have an impact on *Water storage infrastructure*, *Water consumption* and *Irrigation*.

As said, *Housing* has the biggest activity. It has a strong direct impact on *Sanitation system*, *Roads infrastructure*, *Water consumption*, *Water storage infrastructure*, and *Water abstraction*. On the other hand, it is being impacted by 1 variable which is *Legal context*. Thus, by changing the *Legal context*, *Housing* can drastically change. In turn, *Housing* will impact on the 5 variables as just seen. *Water abstraction* and *Water storage infrastructure*, will then have further impact on other variables, etc.

The same logic goes for all the other variables.

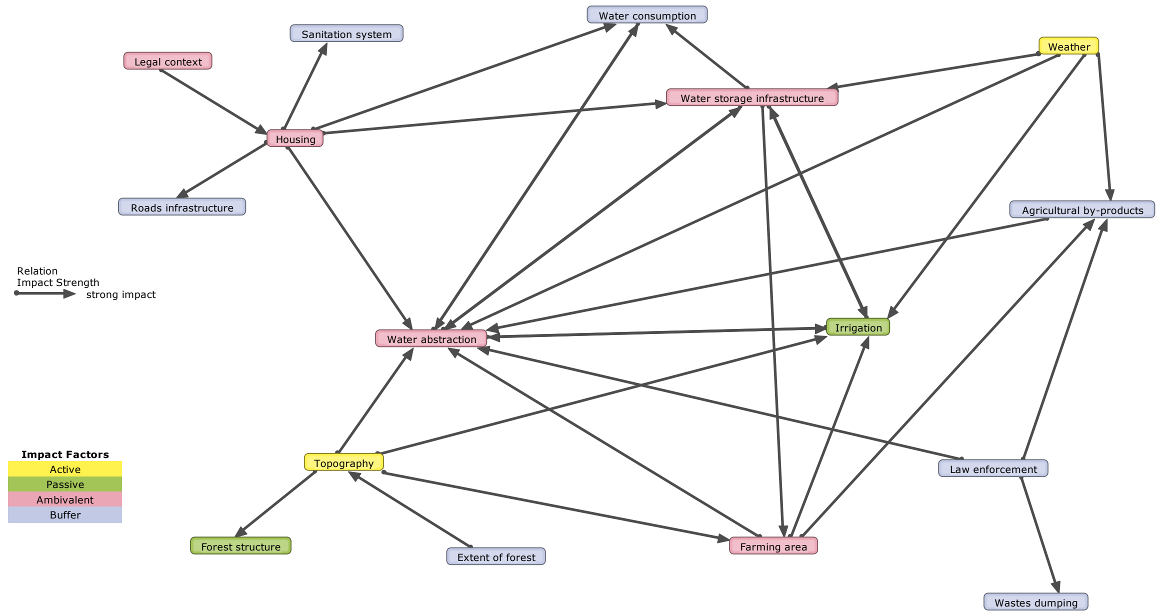


Figure D7: System graph of the 16 variables.
Note: Only strong impacts are shown with the arrows. Active variables are in yellow, passive variables in green, ambivalent variables in pink, and buffer variables in grey.

D2.1.5 Scenario construction

In this section we present the scenarios used for the evaluation by stakeholders. In a first step we briefly explain how we selected the final set of variables to build the scenarios. We then present the four scenarios.

1. Selection of scenario 'descriptors'

Out of the 16 impact factors which we used to represent the system's structure and dynamic, a set of 10 only were kept to reduce complexity of scenarios to be constructed, namely: *Farming area, Legal context, Law enforcement, Sanitation system, Housing, Water storage infrastructure, Agricultural by-products, Extent of forest, Water abstraction, and Weather*. We left out *Irrigation* because it is correlated to *Farming area*, i.e. if *Farming area* increases then *Irrigation* will ultimately increase too. *Roads* and *Waste dumping* were left out as they do not highly affect water provision and retention. Even if *Topography* has a high activity, it was not included in the scenario evaluation, as we think it will not change dramatically over 30 years. *Forest structure* was left out as the definition of the variable is too broad. *Water consumption* was left out as it correlates with *Housing*. If *Housing* increases in our scenarios, *Water consumption* will also increase proportionally. Another impact variable, *Drainage*, was added at this stage. *Drainage* refers to artificial or natural removal of surface and sub-surface water from an area. We realized it was as well an important variable for the retention capacity of the ground, which is one of our focuses.

2. Scenarios

As mentioned in the method chapter (section D1.1.5) scenarios are a combination of all impact factors in different levels. We allocated three levels to each factor: one level represents the current state of the variable (see section D2.1.2), while the other two levels present a possible change with respect to the current state. The different levels of each impact variables are shown in APPENDIX G2 (Table G16).

We defined four scenarios accordingly. These represent four distinct thinkable futures of the Val d'Endor watershed in 30 years, meaning in 2046 (Table D5, for a summary): (1) *Intensive housing*, (2) *Increased farming*, (3) *Better protected water catchment*, and (4) *Better regulated intensification of farming and housing.* The four scenarios are consistent (APPENDIX G2, Table G17).

Scenario 1: *Intensive Housing*

In this first scenario, the number of houses and the area dedicated to housing in Val d'Endor watershed has increased. This means that the population of Val d'Endor has also increased. In this context, there is an increase in the number of septic tanks, which ultimately cause more pollution due to overflow of sewage. Given the increase in population, more water is abstracted from Baie Lazare River for household purposes. As a result, the number of wells and private water tanks increase. As a consequence of increased housing, the farming area will decrease and farming activities will decrease too. It means that agricultural pollution such as pesticides, fertilizers, and animal's excrements will decrease. As the area for housing increases, the area of the forest decreases.

There will be no change to the legal context and law enforcement compared to the current situation. It means that the specific policies, legislation and regulations regarding water quality, water abstraction, water catchment area protection, farming activities, housing, as well as littering are the same as the situation at hand. The same applies to law enforcement. Drainage will stay the same as the current situation. Climate change will also have its impact on the watershed (more precipitation, more flooding, longer drought period).

Scenario 2: *Increased Farming*

In the second scenario, the farming area and the farming activities such as crops and livestock has increased in Val d'Endor. As a consequence, the agricultural pollution caused by pesticides, fertilizers and animal excrement has increased. The farming activities will tend to be more intensive (industrialized). As the farming activities are intensified, more water is abstracted from the Baie Lazare River for the irrigation of crops and water for animals. The number of wells, private water tanks and barrages increase in order to have a better water storage for agricultural purposes. As the area for farming increases, the area of the forest decreases.

On the other hand, the number of houses and thus the number of septic tanks remain constant. There will be no change to the legal context and law enforcement. Drainage will stay the same as the current situation. Climate change will also have its impact on the watershed (more precipitation, more flooding, longer drought period).

Scenario 3: *Better protected water catchment*

In this third scenario, the state of the Val d'Endor remains the same as it is today. It means that farming area and activities, housing, sewage system, size of the forest, storage infrastructures stay as the current situation. But the legislation is tougher. Specific board will be implemented to control water abstraction from Baie Lazare River and to regulate it. Thus, the abstraction of water is much more regulated in order to have a sustainable water supply throughout the year. As a consequence, the amount of water abstracted for irrigation and household purposes will probably decrease. This scenario also comprises better protection of the watershed in general such as forest protection, river protection by avoiding pollution and contamination. There will be strict laws on how to use pesticides and fertilizers in order to reduce to a maximum its impact on the environment. Also, there will be an increase of regulations for the disposal of animal excrement (proper container, far from rivers). Law enforcement will follow the same trend by increasing control and by taking actions in case of trespassing. This scenario is eco-oriented in order to protect the watershed a maximum and minimise the impacts of human on the environment (water, forest). Climate change will also have its impact on the watershed (more precipitation, more flooding, longer drought period). The drainage system will be better managed to mitigate the effect of flooding and erosion.

Scenario 4: *Better regulated intensification of farming and housing*

In this fourth scenario, the farming area and farming activities such as crops and livestock has increased in Val d'Endor. Since the legislations and law enforcement are tougher, the agricultural pollution from pesticides, fertilizers and animal excrement will decrease. Furthermore, the number of houses and the area dedicated to housing in Val d'Endor watershed increases as well. The increase of farming and housing is though limited by the laws and legislations which are tougher and will be made to protect the forest and rivers in the watershed. The intensification of housing will take place in area where housings are already present and the same for farming. This general increase will obviously slow down after a while as the legal context will not allow the infinite extension of farming and housing. Given the general increase of farming and housing, the size of the forest decreases a bit (but still protected by legislations), but some area of the forest will be completely protected (for example area where native species are highly present).

As a consequence of this increase, two alternatives are possible concerning sewage: a centralized sewage system or better-managed septic tank system (no overflow and no pollution of surface water). Moreover, more water is abstracted from the Baie Lazare River because of the increase of population and farming (but it will be highly regulated). Also, the number of wells, private water tanks and barrages increase in order to have a better storage of water. Climate change will also have its impact on the watershed (more precipitation, more flooding, longer drought period). The drainage system will be better managed to mitigate the effect of flooding and erosion.

Table D5: Summary of the four scenarios.
Note: The levels of the impact variables describe a change from the current state situation. i.e. “=” no change compared to current state; “↗“ means increase compared to current state; “↗“ means decrease compared to current state.

		Scenario 1	Scenario 2	Scenario 3	Scenario 4
		« Intensive housing »	***« Increased farming »***	***« Ecosystem services based scenario »***	***« Better regulated intensification of farming and housing »***
Impact variables	*Farming area*	↙	↗	=	↗
	Agricultural by-products	↙	↗	↙	↗
	Housing	↗	=	=	↗
	Sanitation system	↗	=	=	↗
	Water storage infrastructure	↗	↗	=	↗
	Water abstraction	↗	↗	=	↗
	Extent of forest	↙	↙	=	↙
	Legal context	=	=	↗	↗
	Law enforcement	=	=	↗	↗
	Drainage	=	=	↗	↗
	Weather	shift due to climate change	shift due to climate change	shift due to climate change	shift due to climate change

D2.2 Scenario evaluation

In this section, the four different scenarios presented are referred to as scenario 1 to 4 and are described in Table D6 below.

Table D6: Abbreviations and corresponding names of the scenarios used in this section.

Scenarios	Abbreviations	Corresponding names
Scenario 1	S1	*Intensive housing*
Scenario 2	S2	*Increased farming*
Scenario 3	S3	*Better protected water catchment*
Scenario 4	S4	*Better regulated intensification of housing and farming*

D2.2.1 Criteria selection

To evaluate the scenarios in a meaningful way, we need to find criteria that are accurately linked to the object of the evaluation: the scenarios. We came up with five different criteria (Table D7). These five criteria cover the most important aspects of the watershed: freshwater, land use development, environmental awareness and major threats due to climate change.

One can see on Figure D8 the impacts of our 11 variables on our criteria. For a better comprehension of the system, *Water supply* was subdivided in two: water quality and water availability. One can see that water quality and availability are the most impacted by our variables. Water availability is impacted by 9 variables and water quality by 5. *Retention capacity and flood protection* arrives in third position with 4 variables impacting this criterion. Concerning the impact variables, *Legal context* affects 5 criteria. Then, *Housing* has an impact on 4 criteria. Finally, *Farming* and *Extent of forest* impact 3 criteria. Figure D8 can be seen as a verification tool of the reduced set of impact variables.

With Figure 3, we wanted to link criteria with the 11 impact variables and show that the criteria very well cover all of them. Indeed, one can affirm that the variables chosen are relevant.

Table D7: List and definition of the 5 criteria.

Criterion	Definition
Water supply	It refers to the availability and quality of fresh water throughout the year within the Baie Lazare River.
Housing and infrastructure	It refers to the development of housing, infrastructures (hospitals, schools, official buildings, shops, etc.), roads, etc. in Val d'Endor water catchment.
Farming development	It refers to the development of farming activities and area in Val D'Endor water catchment.
Environmental protection	It refers to the protection of the Val d'Endor water catchment (forest and river).
Retention capacity and flood protection	It refers to the water retention capacity of the ground in Baie Lazare watershed (as forest infiltration and slows runoff in a watershed, buildings and constructions will reduce the water retention capacity and increase run-off of an area). Reducing the retention capacity will ultimately increase the risk of flooding.

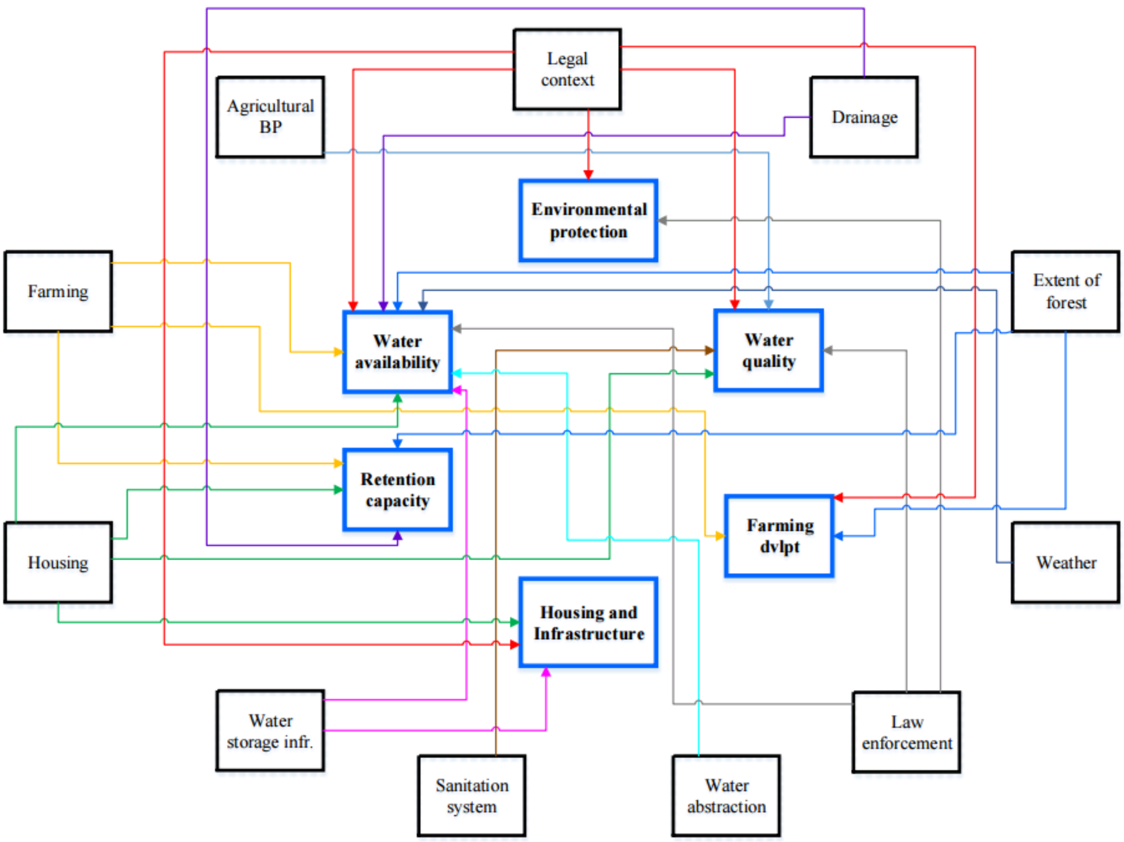


Figure D8: Relations between the reduced set of impact variables (black rectangle) and the criteria (blue rectangle).

D2.2.2 Overall evaluation

In this section we present the results of the desirability and probability evaluations of the scenarios (1) by all stakeholders, (2) by each stakeholder group, and (3) the respective comparison of stakeholder groups.

1. Desirability and probability – all stakeholders

In Figure D9, the mean values of the evaluation of desirability versus probability of all stakeholders are plotted. Overall, the desirability (Table D8) of scenarios varies from *N*=54, *M*=3.75, *SD*=2.77 (*Intensive housing*) to *N*=57, *M*=6.68, *SD*=2.55 (*Better regulated intensification of farming and* *housing*), i.e. there are significant differences between the four scenarios ($F(3, 221) = 12.68$, $p < .001$). *Intensive Housing* (scenario 1) as the least desirable scenario is significantly different from all the other scenarios (Tukey's multiple comparison test see APPENDIX G2 (Table G19)). *Better regulated intensification of farming and housing* (scenario 4) has the highest overall desirability score, although it is not significantly different from *Better protected water catchment* (scenario 3) (Tukey's test see APPENDIX G2, Table G19). In contrast, the probability received similar values (see Table D8), i.e. no significant differences between the scenarios ($F(3, 220) = 1.68$, $p = .17$).

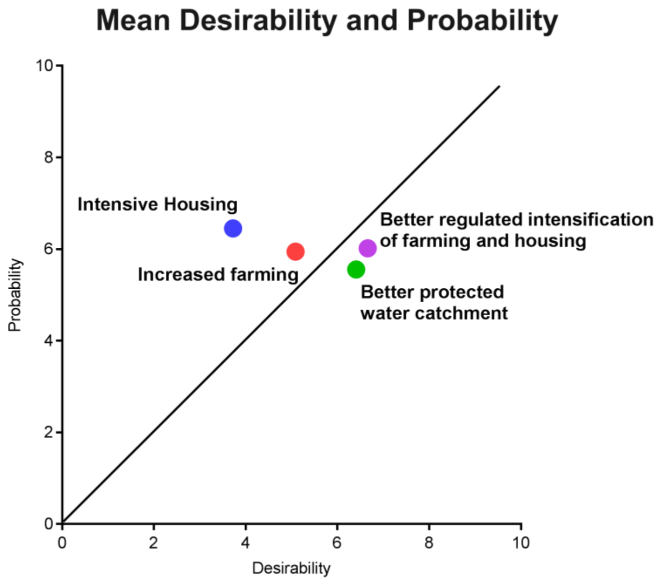


Figure D9: Overall Desirability versus Probability (all stakeholder confounded) for each scenario.
Note: 0 = not at all desirable/probable; 10 = very desirable/probable.

Table D8: Mean (*M*) and Standard deviation (*SD*) values for the desirability and probability of the four scenarios (all stakeholders).
Note: Desirability/Probability of scenarios 1-4. *N* stands for sample size.

Values	**Desirability**				**Probability**			
	S1	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**
N	54	57	57	57	54	57	57	56
M	3.75	5.18	6.32	6.68	6.46	5.91	5.47	6.02
SD	2.77	3.04	2.64	2.55	2.27	2.19	2.55	2.30

2. <u>Desirability and probability – by stakeholder groups</u>

Figure D10 represents desirability vs. probability plots of the four scenarios for the seven stakeholder groups. One can observe a general pattern in all scenarios: scenario 1 (S1) and scenario 2 (S2) are evaluated as more probable than desirable by most of stakeholder groups while scenario 3 (S3) and scenario 4 (S4) are evaluated more desirable than probable.

<u>Desirability</u>

Overall, in terms of desirability stakeholder groups evaluated S1, and S2 significantly different, while S3 and S4 were not (Table D9). We decided that S4, which has a p-value equal to 0.05, is not significant. Indeed, no significant results were found in the Tukey's multiple comparison test (APPENDIX G2, Table G24). Both S3 and S4 are on average evaluated above 5 (APPENDIX G2,

Table G22 and G23). A more detailed analysis of each scenario is shown below. All Tukey's multiple comparison tests can be found in the APPENDIX G2 (Table G20 and G21).

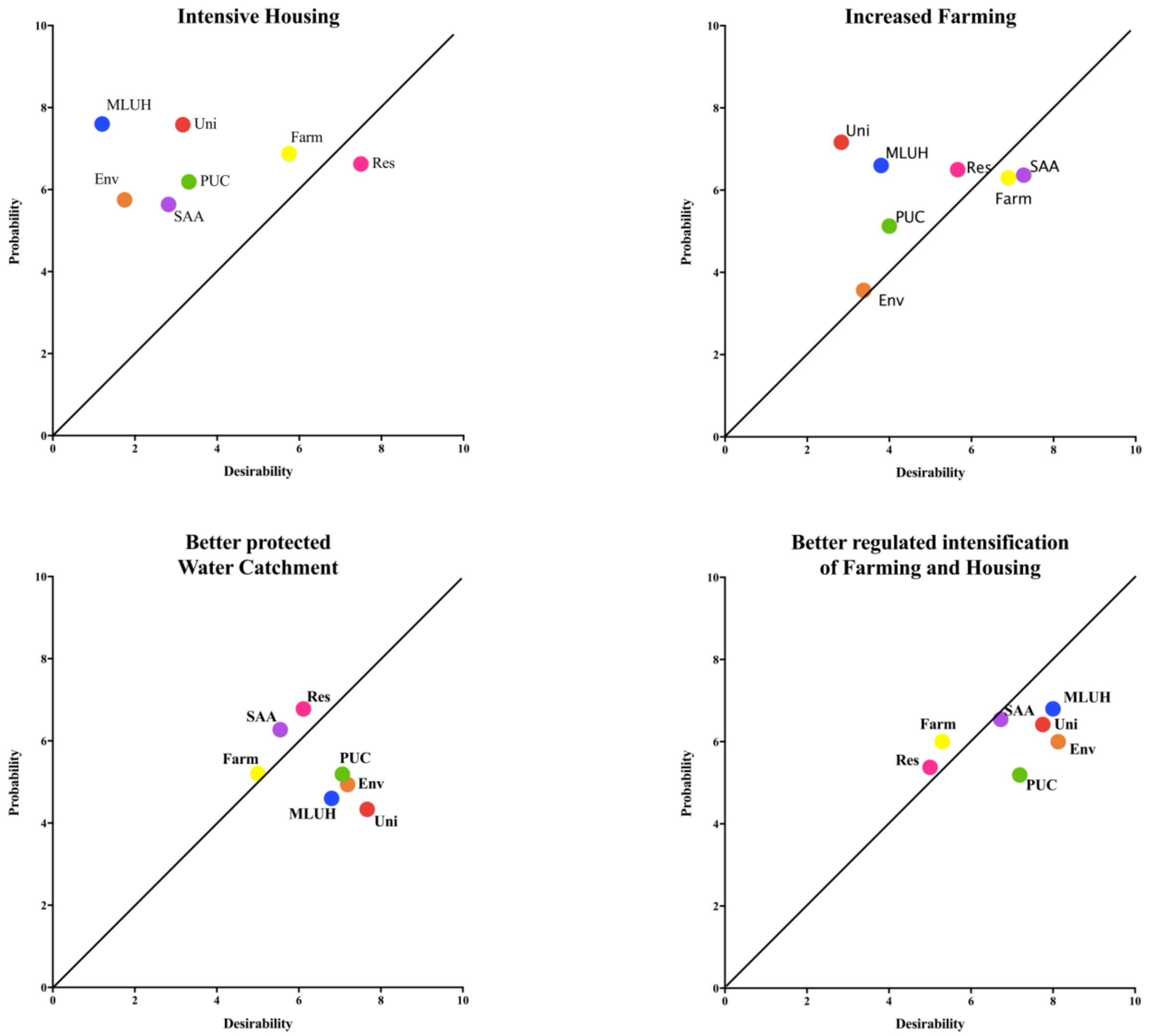


Figure D10: Desirability versus Probability (each stakeholder) for each scenario.
NOTE: 0 = not at all desirable/probable; 10 = very desirable/probable. Stakeholders' abbreviations are: MLUH (Ministry of Land Use and Housing), Uni (University of Seychelles), Farm (farmers), Res (residents), Env (environmental group), SAA (Seychelles Agricultural Agency), and PUC (Public Utilities Corporation).

Table D9: One-Way ANOVA results for the desirability of each scenario among stakeholder groups.
Note: Significant results are shown in orange.

Scenarios	One-way ANOVA
S1	F (6, 47) = 9.37, p < .001
S2	F (6, 50) = 3.71, p = .004
S3	F (6, 50) = 1.14, p = .35
S4	F (6, 50) = 2.30, p = .05

S1 is desired the most by the residents (n=8, M=7.50, SD=2.07) and farmers (n=8, M=5.75, SD=2.05), while MLUH (n=5, M=1.20, SD=1.79), UniSey (n=6, M=3.17, SD=2.16), SAA (n=11, M=2.82, SD=1.89) and the environmental (n=8, M=1.75, SD=1.69) groups are not thrilled by it.

There is less disagreement among the stakeholder groups for S2. Indeed, Tukey's multiple comparison test (APPENDIX G2, Table G21) indicates that only the SAA (*n*=11, *M*=7.27, *SD*=1.49) disagree significantly with both, the UniSey (*n*=6, *M*=2.83, *SD*=2.42) group and the environmental group (*n*=8, *M*=3.38, *SD*=3.15), while no further significant differences can be found among the other groups.

Probability

One-Way ANOVA statistical test (Table D10) indicates that there are significant differences among the seven stakeholder groups for the S2 only. However, Tukey's multiple comparison test shows that only the environmental group (*n*=8, *M*=3.56, *SD*=2.00) and UniSey (*n*=6, *M*=7.17, *SD*=2.54) disagree significantly in their judgments about how probable this scenario is (APPENDIX G2, Table G25).

Table D10: One-Way ANOVA results for the probability of each scenario among stakeholder groups.
Note: Significant results are shown in orange.

Scenarios	One-way ANOVA
S1	F (6, 47) = 0.88, p = .515
S2	F (6, 50) = 2.81, p = .020
S3	F (6, 50) = 0.96, p = .461
S4	F (5, 42) = 0.53 p = .753

3. Desirability and probability – comparison of stakeholder groups

In this section, we are presenting the same data as in the previous section but this time each stakeholder group is analysed separately (see APPENDIX G3, Figure G7).

Desirability

All the groups, except farmers and residents, evaluated the desirability of the four scenarios significantly different (Table D11).

Table D11: One-Way ANOVA results for the desirability of each stakeholder group.
Note: Significant results are shown in orange.

Stakeholder group	One-way ANOA
Environmental group	F (3, 28) = 11.84, p < .001
PUC	F (3, 28) = 5.81, p = .003
SAA	F (3, 40) = 9.18, p < .001
UniSey	F (3, 20) = 7.15, p = .002
MLUH	F (3, 16) = 6.12, p = .006
Residents	F (3, 31) = 1.07, p = .37
Farmers	F (3, 34) = 1.76, p = .17

For the environmental group**,** Tukey's multiple comparison test (APPENDIX G2, Table G26) indicated no significant difference between S1 (*n*=8, *M*=1.75, *SD*=1.69) and S2 (*n*=8, *M*=3.38, *SD*=3.15), and between S4 (*n*=8, *M*=7.19, *SD*=3.00) and S3 (*n*=8, *M*=8.13, *SD*=1.79). However, the latter two scenarios are clearly preferred against the former two ones.

PUC seems to have a preference for both S4 (*n*=8, *M*=7.19, *SD*=2.10) and S3 (*n*=8, *M*=7.06, *SD*=2.68). These two scenarios are not significantly different from each other in terms of desirability, whereas both of them are significantly different from S1 (*n*=8, *M*=3.31, *SD*=2.12) (Tukey's multiple comparison test, APPENDIX G2, Table G27).

S1 (*n*=11, *M*=2.82, *SD*=1.89) is significantly less desirable than the three other scenarios for the SAA group. No significant differences were found among S2 (*n*=11, *M*=7.27, *SD*=1.49), S3 (*n*=11, *M*=5.46, *SD*=2.62) and S4 (*n*=11, *M*=6.73, *SD*=2.49) (Tukey's multiple comparison test, APPENDIX G2, Table G28).

The UniSey group clearly prefers both S4 (*n*=6, *M*=7.75, *SD*=2.19) and S3 (*n*=6, *M*=7.67, *SD*=3.09) against S1 (*n*=6, *M*=3.17, *SD*=2.16) and S2 (*n*=6, *M*=2.83, *SD*=2.42) (For further details see Tukey's multiple comparisons test, in APPENDIX G2, Table G29).

For MLUH, S1 (*n*=5, *M*=1.20, *SD*=1.79) is much less desirable than S3 (*n*=5, *M*=6.80, *SD*=2.39) and S4 (*n*=5, *M*=8.00, *SD*=2.12) (Tukey's multiple comparison test, APPENDIX G2, Table G30).

Probability

For all the different stakeholder groups, the difference of probability between the four scenarios for each stakeholder group is not significant (one-way ANOVA, $p>0.05$) (Table D12).

Table D12: One-Way ANOVA results for the probability of each stakeholder group.

Stakeholder group	One-way ANOVA
Environmental group	F (3, 28) = 2.42, p = .08
PUC	F (3, 28) = 0.39, p = .76
SAA	F (3, 40) = 0.33, p = .80
UniSey	F (3, 20) = 2.72, p = .07
MLUH	F (3, 16) = 1.54, p = .24
Residents	F (3, 30) = 0.43, p = .73
Farmers	F (3, 34) = 0.89, p = .45

To summarize, five stakeholder groups have a preference for *Better protected water catchment* and *Better regulated intensification of housing and farming* scenarios and desire less *Intensive housing* scenario. Unfortunately, residents and farmers outputs did not allow inferring any conclusion about the desirability and probability of each scenario (Table D11 and D12).

D2.2.3 Criteria based evaluation

In this section, we present (1) the performance of the five criteria in the current state, (2) the perception of each criterion in each scenario and (3) the difference among stakeholder groups concerning the perception of each criterion in each scenario. As a reminder, the criteria are *Water supply, Housing and infrastructure, Farming development, Environmental protection,* and *Retention capacity and flood protection.*

1. Performance of criteria in current state

First, we present the results of the performance of each criterion in the current state situation by all participants of the survey (Figure D11). One can observe that the five criteria were evaluated around the average which is 4 on our scale. The last two ones, *Environmental protection* and *Retention capacity and flood protection* are both just below the average. See APPENDIX G2, Table G31 for mean and SD values.

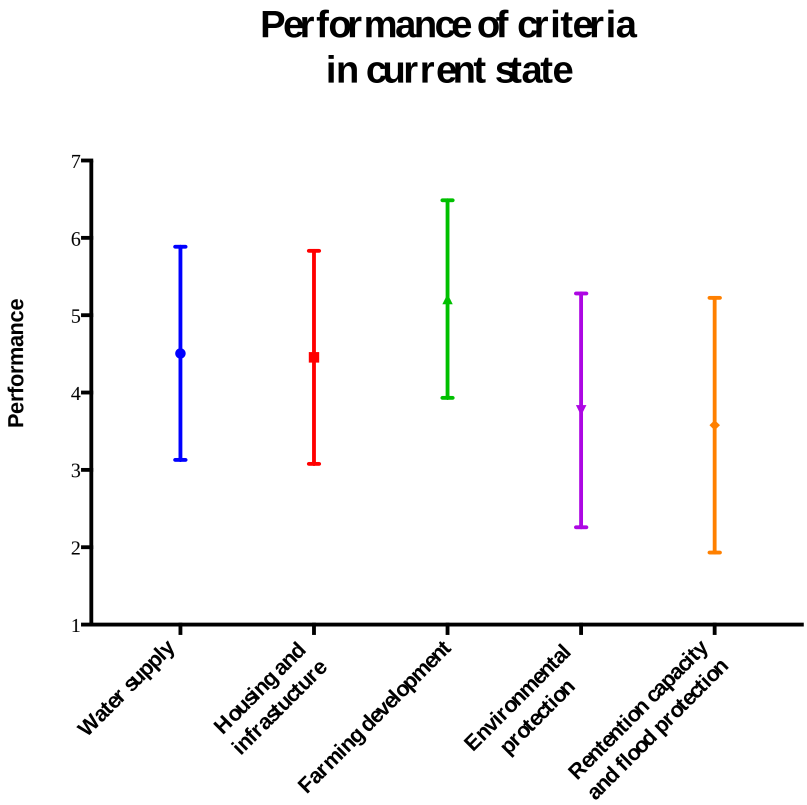


Figure D11: Performance of the current situation along the five criteria (all stakeholders).
Note: The scale goes from 1 (very bad) to 7 (very good).

2. <u>Evaluation of scenarios along the criteria – all stakeholders</u>

For the perception of the criteria in the different scenarios another scale was used, varying from -3 to +3, i.e. -3=much less satisfied; -2=less satisfied; -1=slightly less satisfied; 0= same as current state; +1=slightly more satisfied; +2=more satisfied; and +3= much more satisfied. Figure D12 displays the evaluation of the four scenarios along the five criteria (one graph for each criterion). In general, S1 and S2 receive lower values by the stakeholders in most criteria compared to the current situation, while people are more satisfied with S3 and S4 in all five criteria. Accordingly, all scenarios vary significantly in all five criteria as Table D13 indicates.

Table D13: One-Way ANOVA results for the five criteria among the four scenarios.
Note: Significant results are shown in orange.

Criteria	One-Way ANOVA
Water supply	F (3, 219) = 13.60, p < .001
Housing and infrastructure	F (3, 221) = 10.03, p < .001
Farming development	F (3, 221) = 15.79, p < .001
Environmental Protection	F (3, 220) = 25.14, p < .001
Retention capacity and flood protection	F (3, 221) = 19.47, p < .001

People are more satisfied about S4 (n=54, M=1.54, SD=1.25) and S3 (n=56, M=0.82, SD=1.64) in terms of the *Water supply* criterion compared to the two other scenarios, especially compared to S1 (n=53, M=-0.32, SD=1.85) (Tukey's multiple comparisons test, APPENDIX G2, Table G32).

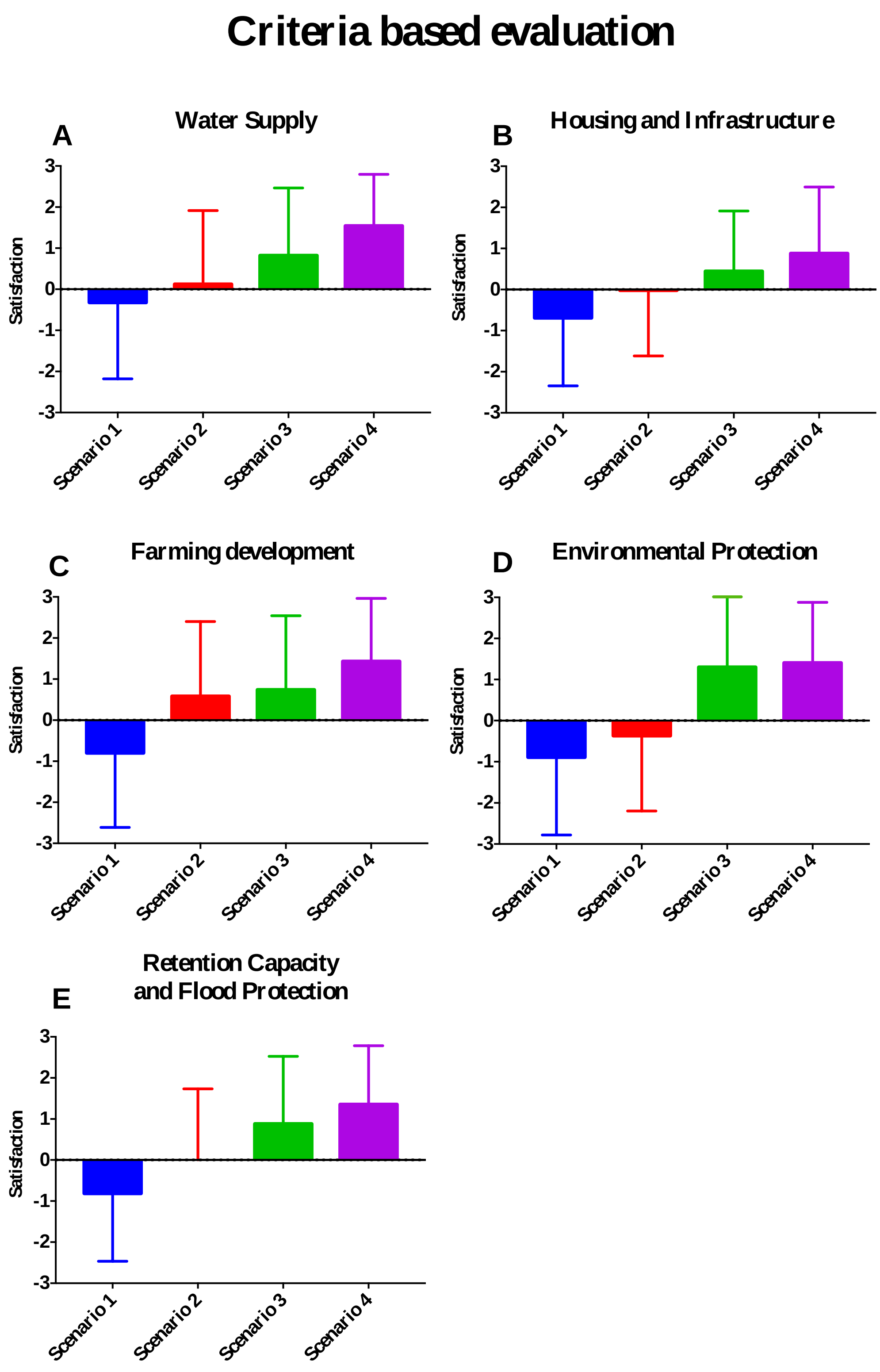


Figure D12: Overall satisfaction (mean) about the 5 criteria in the four scenarios compared to the current state.

Note: The zero-axis (0) represents the current state. Values above or below this line mean that participants are more/less satisfied with the given scenario in respective criteria compared to the current state. (A) *Water supply* by scenarios. (B) *Housing and infrastructure* by scenarios. (C) *Farming development* by scenarios. (D) *Environmental protection* by scenarios. (E) *Retention capacity and flood protection* by scenarios. Scale goes from -3 to +3 with -3=much less satisfied; -2=less satisfied; -1=slightly less satisfied; 0= same as current state; +1=slightly more satisfied; +2=more satisfied; and +3= much more satisfied.

One can observe a similar pattern in terms of the *Housing and infrastructure* criterion: S3 (*n*=56, *M*=0.44, *SD*=1.46) and S4 (*n*=57, *M*=0.87, *SD*=1.61) are clearly preferred scenarios compared to S1 (*n*=55, *M*=-0.69, *SD*=1.64) (Tukey's multiple comparisons test, APPENDIX G2, Table G33).

In terms of the criterion *Farming development* (*n*=55, *M*=-0.80, *SD*=1.80), S1 differs significantly from the three others scenarios (Tukey's multiple comparisons test, APPENDIX G2, Table G34). S1 is much less preferred along this criterion than the current state.

In terms of *Environmental protection* criterion the stakeholders are more satisfied with S3 (*n*=56, *M*=1.30, *SD*=1.71) and S4 (*n*=57, *M*=1.40, *SD*=1.47), compared to S1 and S2 (Tukey's multiple comparisons test, APPENDIX G2, Table G35).

Finally, S1 again is less satisfying in terms of the criterion *Retention capacity and flood protection* (*n*=54, *M*=-0.81, *SD*=1.64) (Tukey's multiple comparisons test, APPENDIX G2, Table G36) while this criterion is more satisfying in S3 (*n*=57, *M*=0.87, *SD*=1.64) and S4 (*n*=57, *M*=1.35, *SD*=1.43) compared to the current state. All mean and standard deviation data of each criterion in each scenario are provided in APPENDIX G2, Table G37.

3. Evaluation of scenarios along the criteria – by stakeholders groups

In this subsection, we present more detailed results in terms of how the different stakeholder groups perceive the future of Val d'Endor. In general, the groups, as already pointed out before, show different response patterns in terms of how the four scenarios perform in the five criteria. We will now analyse these results in more detail.

In S1, there is a significant difference among stakeholders' perceptions concerning the *Water supply* criterion (Table D14) especially the farmers group which disagree with the environmental group and also with SAA (Tukey's multiple comparisons test, APPENDIX G2, Table G38). Farmers are actually more satisfied about the *Water supply* status (*n*=8, *M*=1.62, *SD*=1.06) in S1 compared to its current status. On the other hand, SAA and the environmental group perceive *Water supply* in S1 to be less good as it is currently (*n*=11, *M*=-0.90, *SD*=1.75 and *n*=8, *M*=-1.50, *SD*=1.60 respectively). No significant difference in perception of the criterion *Water supply* has been found in the three other scenarios (Table D14).

Table D14: One-Way ANOVA results for *Water supply* among the stakeholders for each scenario.
Note: Significant results are shown in orange.

***Water supply* in scenario**	**One-Way ANOVA**
S1	F (6, 47) = 2.97, p = .01
S2	F (6, 51) = 1.71, p = .13
S3	F (6, 50) = 2.09, p = .07
S4	F (6, 51) = 0.48, p = .82

Housing and infrastructure in all four scenarios is not evaluated significantly different by the seven stakeholder groups (Table D15).

Table D15: One-Way ANOVA results for *Housing and infrastructure* among the stakeholders for each scenario.

***Housing and infrastructure* in scenario**	**One-Way ANOVA**
S1	F (6, 49) = 1.86, p = .10
S2	F (6, 51) = 2.19, p = .06
S3	F (6, 50) = 1.46, p = .21
S4	F (6, 51) = 0.75, p = .61

Concerning the *Farming development* criterion, there is a difference in the perception among stakeholders in both S2 and S3 (Table D16). In S2, the UniSey group is less satisfied with this criterion compared to the current state (*n*=7, *M*=-0.70, *SD*=1.97), while farmers on the contrary are more satisfied (*n*=10, *M*=1.90, *SD*=1.19). In S3, again the farmers are more satisfied regarding this criterion compared to the current state (*n*=10, *M*=1.70, *SD*=1.76), while MLUH is less satisfied (*n*=5, *M*=-1.20, *SD*=1.30). The Tukey's multiple comparisons test can be found in APPENDIX G2 (Table G39 and Table G40).

Table D16: One-Way ANOVA results for *Farming development* among the stakeholders for each scenario.
Note: Significant results are shown in orange.

***Farming development* in scenario**	**One-Way ANOVA**
S1	F (6, 49) = 2.22, p = .06
S2	F (6, 51) = 2.51, p = .03
S3	F (6, 51) = 2.69, p = .02
S4	F (6, 50) = 1.17, p = .33

In terms of the *Environmental protection* criterion, there are significant differences among stakeholders in S1 and S2 (Table D17). In the former scenario, farmers are more satisfied in terms of *Environmental protection* (*n*=8, *M*=1.62, *SD*=1.18), while the environmental group, SAA, UniSey group, and MLUH evaluate it the other way around (*n*=8, *M*=-2.37, *SD*=-1.06; *n*=7, *M*=-1.00, *SD*=1.84; M=-2.00, *SD*=.81; *n*=5, *M*=-1.80, *SD*=1.30 respectively). In the latter scenario, the environmental group, and UniSey group are both less satisfied in terms of *Environmental protection* (*n*=8, *M*=-1.75, *SD*=1.38 and *n*=7, *M*=-1.85, *SD*=0.69 respectively). On the other hand, residents and farmers are more satisfied here (*n*=9, *M*=0.77, *SD*=1.48 and *n*=10, *M*=0.90, *SD*=1.72 respectively). The Tukey's multiple comparisons test can be found in APPENDIX G2 (Table G41 and Table G42).

Table D17: One-Way ANOVA results for *Environmental protection* among the stakeholders for each scenario.
Note: Significant results are shown in orange.

***Environmental protection* in scenario**	**One-Way ANOVA**
S1	F (6, 48) = 6.31, p < .001
S2	F (6, 51) = 5.03, p < .001
S3	F (6, 50) = 2.04, p = .07
S4	F (6, 51) = 0.82, p = .55

Finally, no significant difference has been found in stakeholder groups' evaluation of the four scenarios concerning the *Retention capacity and flood protection* criterion (Table D18).

Table D18: One-Way ANOVA results for *Retention capacity and flood protection* among the stakeholders for each scenario.

***Retention capacity and flood protection* in scenario**	**One-Way ANOVA**
S1	F (6, 48) = 0.83, p = .54
S2	F (6, 51) = 1.39, p = .23
S3	F (6, 51) = 1.00, p = .43
S4	F (6, 51) = 1.17, p = .34

To summarize this section, all criteria were evaluated as less satisfying in the *Intensive housing* and *Increased farming* scenarios for all stakeholder groups confounded, while they were evaluated as more satisfying in the two other scenarios.

D3 Discussion

In this section, we will discuss results about (1) the current state of the watershed focusing on water quality and availability and (2) the scenario evaluation. The first will allow to further answer the first part (a) of the research question, and the latter the second part (b) of it.

D3.1 Current State

As seen in the results, we identified 13 elements that may have an impact on the ecosystem services of the Val d'Endor water catchment, more particularly on freshwater availability and/or quality and water retention capacity. These elements are (1) Topography, (2) Land allocation, (3) Housing, (4) Agriculture, (5) Waste management, (6) Water management, (7) Climate, (8) Forest, (9) Connectivity, (10) Environmental protection, (11) Health protection, (12) Legal context, and (13) Law enforcement.

Topography is important because it shapes the water flow and is a determinant factor for the destination of stormwater. Thus, depending on the topography and the type of soil, stormwater can either join the channel network or infiltrate into the soil (Price, 2011). The rate of infiltration is reduced by impervious surfaces (Price, 2011) such as roads, house foundations, parking lots, etc. Thus, urbanization decreases water infiltration and retention, and increases surface runoff after (heavy) rainfall events (Diersing, 2009). Ultimately it increases the risks of flooding and water scarcity during extreme events. Furthermore, with climate change, it has been predicted that the dry spell will be longer in Seychelles (Parry, 2007). This means that the flows in the rivers will reduce drastically; hence affects the amount of water that can be abstracted from rivers. In other words, water availability will be reduced.

It therefore seems important to have a good water management in order to secure water supply in the future. For this, abstraction should not exceed the natural recharge (Environment Agency, 2009). In the Val d'Endor watershed, water is abstracted for housing purposes and for irrigation by PUC, SAA, residents, and farmers. Thereby, water management seems complicated because different entities, each with different interests, compete for the same resource. Indeed, PUC provides water principally for household, while SAA provides water for irrigation. On the other hand, farmers and residents abstract the water for their needs and this often without any authorization. This points out that there is lack of law enforcement and there might be a lack of proper regulations as well. Indeed, there are only eight people in charge of enforcing the law at the MEECC (Interviewee 10). In addition to skilled personnel, good water management also needs proper infrastructure (Srinivasan et al., 2013). Indeed, nearly half of the water that is distributed on Mahe is lost because the pipe system is outdated (Interviewee 3). This problem adds further to the risks of water scarcity.

To sustain water supply, water quality is another important aspect. Degradation of water can come from different sources and depends on the type of land use (Weatherhead and Howden, 2009). In Val d'Endor, the quality of water is influenced by agricultural activities and household related activities. In agriculture, the use of pesticides and fertilizers, animals' faeces, and dead animals which are not properly disposed, can ultimately pollute freshwater through runoff, especially when the farms are above the catchment zone. This might also have health's impact. In Val d'Endor, septic tanks and soak away pits are used for sewage treatment and disposal. This is not sustainable solution considering the increase of housing on the island (SSDS, Vol.2). Furthermore, it is thought to deteriorate water quality of most rivers, because water going in soak away pits percolates into the soil (Interviewee 11). Other practices such as littering and car dumping that can further impact water quality have been observed in the Val d'Endor watershed. The green bins for disposing household wastes are supposed to be collected on a daily basis, but sometimes this is not the case and it can potentially lead to the washing off of wastes into rivers in case of heavy rain. The problem with most of these types of pollution is that they are nonpoint source pollutions which means that the identification and reduction of the source is complicated. Indeed, the responsibility for the nonpoint source pollution is spread among the population (Carle et al., 2005) living in the watershed. In this context, water quality management is challenging and needs respective efforts in communicating effects of such inappropriate practices.

In general, our investigation of the current state suggests that the watershed needs to be better managed which includes appropriate regulations and law enforcement and improved protection because of the ecosystem services it provides for human wellbeing (Postel and Thompson, 2005). Usually, watersheds are undervalued and unprotected. This is the case in Seychelles which has no specific laws for protecting them.

D3.2 Scenario evaluation

As mentioned earlier the scenarios were evaluated by the stakeholders in terms of desirability and probability and more in detail via criteria. The goal was to identify stakeholders' perception of the current state and potential developments the area could undergo. One particular interest was to learn about areas of agreement and disagreement among the stakeholders which may help establishing acceptable policies and management strategies. We first discuss results about the desirability and probability evaluation, followed by the criteria based evaluation and we will finally present the concerns of the different stakeholder groups about the water catchment.

1. <u>Desirability and probability</u>

The results on the desirability of the scenarios show, generally, a preference for the *Better regulated intensification of housing and farming* and *Better protected water catchment area* (all stakeholders agreed). The two scenarios include both a stricter legal regulation (for the protection of rivers, forest and land in catchment areas) and law enforcement. In essence, this means that stakeholders think there is a need for improving laws and regulations, and law enforcement in order to improve the protection status of the water catchment.

However, when we compare the stakeholder groups, we can observe a more sophisticated picture. Both residents and farmers prefer an intensification of housing in the watershed whereas UniSey and the environmental group totally disagree with them. This can be explained by different interests. For example, farmers and residents want to stay in their living area and want to see respective development which includes population growth and increase of farming activities. On the contrary, UniSey and the environmental group would prefer to protect the watershed from increased human development, because it would include an increase of infrastructure and as already mentioned earlier, development would increase the risk for water scarcity in the area.

A similar pattern can be observed concerning the *Increased farming* scenario. This is probably because farming activities include irrigation and potential contaminations of the freshwater as discussed above. On the other hand, this is the preferred scenario by SAA. This seems quite logical as SAA is in favour of a growing agriculture on Mahe to achieve food security and to rehabilitate and further develop the national agricultural sector. Again, one can see that own interests drive choices and preferences for a particular scenario.

As seen in the results part, the different stakeholders were quite in favour for the two last scenarios: *Better regulated intensification of housing and farming* and *Better protected water catchment area*. Moreover, no dissent for the desirability of these two scenarios has been found among the seven stakeholder groups. In essence this means that these scenarios might find support by all groups and therefore be promising starting points for a more sustainable and accepted solution.

While the response pattern on desirability is rather clear, the evaluation pattern concerning the likelihood of the occurrence of scenarios is ambiguous. There is no scenario which is judged as most probable to occur. Rather all seem to have the same probability to occur with a slight tendency for the scenario *Intensive housing*. This agreement regarding the probability judgments among the stakeholder groups may be explained with the fact that it is very hard to predict the future state of an area. Indeed, the Seychelles have gone through a tremendous change in the last 15 years which may make people think that even undesired trajectories may occur.

To summarize, respondents have a clear understanding of what they prefer and what development for the area they would like to see. However, they are rather helpless in predicting if their preferences will occur in the future. This can be partly explained by the fact that nobody can predict the future because many internal and external factors are influencing the further development of the area.

2. <u>Criteria based evaluation</u>

Criteria based evaluation is meant to trigger respondents' analytical mode and should provide a more comprehensive picture. In contrast to the holistic evaluation of the scenarios presented earlier, the criteria based evaluation provides detailed information on what aspects participants are more/less satisfied regarding the four different scenarios compared to the current state.

<u>Criteria values – current state</u>

Criteria based evaluation of the current state shows values around the mean. In other words, the five criteria in the current state perform on average neither very good, nor very bad. Nevertheless, there is a wide SD, this means that people vary massively in their judgments. There is room for the better or for the worse depending on the respective position of the stakeholder. However, it might strongly depend on what is at stake for the different stakeholders.

<u>Criteria values – scenarios</u>

Overall, participants seem to be less satisfied with *Intensive housing* and *Increased farming* in terms of all criteria compared to the current state. In the two other scenarios, *Better regulated intensification of housing and farming* and *Better protected water catchment area*, the overall response pattern is the other way round, i.e. participants are more satisfied regarding all criteria in these two scenarios than in the current state. Results suggest again that respondents want to have an improved legal framework and a strict implementation and enforcement of existing law.

However, when we compare the stakeholders groups, it is striking that farmers and residents reveal a different response pattern than the other groups. This becomes obvious in terms of the criterion *Environmental protection* in the *Intensive housing* scenario. Indeed, farmers and residents are more satisfied about *Environmental protection* in this scenario compared to the current state, although this scenario has the same legal context and the law enforcement than in the current state. Another example is when farmers are more satisfied about *Water supply* in the *Intensive housing* scenario, although *Water supply* will decrease due to higher water demand by increased population. This is an indication that these two groups might have at least partially misinterpreted the task. Thus, we will not discuss more in detail the results of farmers and residents in the rest of this section.

In all scenarios, no dissents among the other stakeholder groups concerning the evaluation of the five criteria were observed. This further confirms that people are in general more satisfied about the *Better regulated intensification of housing and farming* and *Better protected water catchment area* scenarios as already seen in the desirability evaluation. Thus, in terms of further management strategies this is a promising result as it suggests agreement at least on the generic level.

3. Concerns of the different stakeholder groups about the water catchment

From the open questions at the end of the questionnaire, one can observe that all stakeholder groups have concerns about water catchment. For example, UniSey and environmental group are preoccupied by pollution of freshwater, protection of forest, availability of water and have concerns about land ownerships as well. From their point of view, it is not clear who is responsible for the management of the water catchment areas. Indeed, major rivers and wetlands are found on private properties and this can impede government decisions. Indeed, government has limited power when it comes to private property. SAA is concerned about water availability and would recommend to better manage water catchment and to increase water retention/storage in the soil thus prolonging availability during dry spells. PUC is highly concerned by water quality. They are worried about anthropogenic pollution of river, and would recommend enforcing the law properly to see illegal polluting activities disappear in the future. MLUH felt not directly concerned by water catchment. People were personally preoccupied that water catchment areas are decreasing and becoming more polluted which could potentially compromise the health. Residents and farmers have general preoccupations on water availability and quality in the future for their own interest. These perceptions demonstrate that water catchments impact everyone and its protection is in high demand from all of our stakeholder groups.

Concerning the future of Val d'Endor watershed area, all stakeholder groups except farmers expect more housing and farming activities in the area. Farmers see an increase in housing yet a decrease of farming. This opinion can be explained as the young generation is less interested in working in the agricultural sector. Apparently more and more people tend to work in the city. All stakeholder groups see a development in terms of housing in the area and are concerned that it will lead to habitat destruction and further water pollution. They all agree that increasing housing and infrastructure will lead to more surface runoff, soil erosion and less retention of water. Also, there is consent that the government should be consistent with their regulations and that law should be properly enforced. Furthermore, an increase in farming activities might bring more contaminants to the water sources and impact the water quality. Sustainable development and proper planning are therefore critical for the future of the Val d'Endor watershed.

D4 Limitation

The qualitative system analysis, as its name implies, is based on qualitative data. Indeed, there is a lack of quantitative data in the Seychelles especially concerning the Val d'Endor area. Nevertheless, we managed to gather a lot of information via our multiple interviews, desk research, and own observations which, in general, provide a comprehensive picture of the structure, the characteristics, and the dynamic of the area.

The current state description was mostly done on the basis of experts' interviews. This implies the risk that the description of the current state reflects personal opinion. However, we included all the major perspectives in our investigation which makes its outcome more robust. Indeed, most of the points in the description were inferred by several interviewees which reduced this risk and allow us to come up with a good description of the Val d'Endor watershed area.

For the system analysis, two main difficulties were encountered, while completing the impact matrix and inconsistency matrix. On one side, there was a lack of information that did not allow the authors to understand the full complexity of every impact factor and their links between them. Accordingly, even the impact matrix (i.e. the evaluation of the direct impacts from one impact factor to another) evaluated by four different experts resulted partly in ambiguous numbers, meaning that the final matrix is dependent on the previous knowledge of each expert and their intuitive evaluation. However, as the matrix was completed by 6 people, we were able to minimise potential misjudgments that could have influenced the further analysis. On the other hand, the two authors only filled out the inconsistency matrix (which is the basis for the scenario construction), and no verification by expert was done. It means that the results of this matrix may not be completely reliable. However, at this stage of the project the two authors were already skilled and equipped with sufficient knowledge to ensure that the four scenarios can be considered valid. Moreover, experts' validation on the four scenarios suggested no inconsistencies.

Finally, a major limitation that should be pointed out about the scenario evaluation refers to the complexity of the evaluation process. Results suggest that residents and farmers, who were not familiar with some of the concepts of this study, had some difficulties completing the questionnaire (specifically in the criteria based evaluation). The problem was, first, a matter of language constraints, as some of them do not understand or speak English very well. However, a local resident helped for the translation of the questionnaire. For this reason, there might have been some interpretation biases; still we assume that the major problem comes from the questionnaire itself. The criteria's scale was too abstract and probably not in all aspects self-explanatory. This means that if some people did not answer properly the evaluation, the mean of the whole group is influenced. This is due to small sample size. These uncertainties concerning the quality of the responses of the desirability/probability and the criteria based evaluation for farmers and residents were taken into account in our analysis of the results. However, the results from the other group are reliable. We would suggest improving this evaluation by doing shorter questionnaires for residents and farmers asking them only to rate the desirability and probability of each scenario and carry out the criteria based evaluation with experts only.

In general, the collection of data in Seychelles was limited by time. The authors only had 3 months to collect all data necessary for their analysis. Nevertheless, it was managed to collect all important data to understand the complexity of the system and to describe it. The scenarios reflect possible future states of the watershed and reliable criteria were defined to evaluate those scenarios regarding human activities and their impacts on water supply and retention. Scenarios are, as said earlier, means to deal with uncertainties of upcoming development. Insofar, they met the needs of this study. To close this short excursus into some limitations of our study, we would like to stress that the intensive and fruitful cooperation of all the stakeholders from diverse domains ensured to have a comprehensive systemic picture of the Val d'Endor water catchment area. The approach chosen might be used for other analysis of other catchment areas in the Seychelles.

E. Conclusion

In order to answer our research question (How can Val d'Endor water catchment (a) be characterized in terms of ecosystem services focusing on water provision and retention, and (b) how can these services be evaluated?"**)**, we have seen two important perspectives for characterizing and evaluating a water catchment area.

Regarding aspects of the vegetation, we characterized and evaluated the forest system. We have seen that the different sites will need targeted rehabilitation according to the species PVs, the distribution patterns and the magnitude of invasions with exotic species, their likelihood to increase/decrease, and finally regarding the vegetation quality of the 10 survey sites. Furthermore, all the data collected will be a useful reference for the post-rehabilitation monitoring and the quality assurance of concrete, future rehabilitation action.

In order to address current and future water challenges at the catchment level in the Seychelles, we have also seen that characterizing the human activities impacting water provision and retention are important. Furthermore, the perception of the people, their social and individual "relations" with ecosystem services allow setting the context and is essential for ecosystem-based management for local and national policy conception as well as for decision-making. The future development of the area should be managed precociously in order to preserve the watershed.

To conclude, this thesis provides a baseline for a more sustainable management of the Val d'Endor water catchment area. Given the outcome of this thesis, the next steps are to develop an appropriate vegetation rehabilitation program, design an action plan to improve the ecosystem services of the water catchment, mitigate the problems regarding human impacts and water quality and availability by assigning responsibilities and concrete action to stakeholders and communities, and finally monitor the outcomes and revise present aspects of research according to the achievements. Furthermore, the methodology used in this study can be used for the other water catchment area in Seychelles targeted by the EbA project.

F. References

F1 Literature

Ataroff, M., & Rada, F. (2000). Deforestation impact on water dynamics in a Venezuelan Andean cloud forest. *AMBIO: A Journal of the Human Environment*, *29*(7), 440-444.

Bader, B. & Hendry, B. (2007). Evaluation of the Ecological Significance of the Palm Forest La Reserve on Mahé Island, Seychelles. *Master-Thesis, Institute of Integrative Biology Zurich, ETH, Zurich*

Blossey, B. (1999). Before, during and after: the need for long-term monitoring in invasive plant species management. *Biological Invasions*, *1*(2-3), 301-311.

Böck, D. K., & Oberdiek, J. (2013). Die Wahrnehmung von fließgewässerbezogenen „Ökosystemleistungen "und Konfliktpotenzialen am Fallbeispiel „Flusslandschaft Enns ". *Österreichische Wasser-und Abfallwirtschaft*, *65*(11-12), 418-428.

Bossel, H. (2007). Systems and models: complexity, dynamics, evolution, sustainability. BoD–Books on Demand.

Boyd, J., & Banzhaf, S. (2007). What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics*, *63*(2), 616-626.

Brabec, E. A. (2009). Imperviousness and land-use policy: Toward an effective approach to watershed planning. *Journal of hydrologic engineering*, *14*(4), 425-433.

Brauman, K. A., Daily, G. C., Duarte, T. K. E., & Mooney, H. A. (2007). The nature and value of ecosystem services: an overview highlighting hydrologic services. *Annu. Rev. Environ. Resour.*, *32*, 67-98.

Brauman, K. A., Daily, G. C., Duarte, T. K. E., & Mooney, H. A. (2007). The nature and value of ecosystem services: an overview highlighting hydrologic services. *Annu. Rev. Environ. Resour.*, *32*, 67-98.

Brooks, K. N., Gregersen, H. M., Lundgren, A. L., & Quinn, R. M. (1990). Manual on watershed management project planning monitoring and evaluation.

Bügl, R., Stauffacher, M., Kriese, U., Pollheimer, D. L., & Scholz, R. W. (2012). Identifying stakeholders' views on sustainable urban transition: desirability, utility and probability assessments of scenarios. *European Planning Studies*,*20*(10), 1667-1687.

Byrson, J. M. (2004). What to do when stakeholders matter. *Public Management Review*, *6*(1), 21-53.

Calder, I. R., & Dye, P. (2001). Hydrological impacts of invasive alien plants.*Land Use and Water Resources Research*, *1*(7), 1-8.

Carle, M. V., Halpin, P. N., & Stow, C. A. (2005). Patterns of watershed urbanization and impacts on water quality1.

Chang Seng, S. D. (2007). Climate Variability and Climate Change Assessment for the seychelles, second national Communication (snC). In *Under the United nations Framework Convention on Climate Change (UnFCCC), UnDP, seychelles*.

Checkland, P., & Scholes, J. (1999). Soft Systems Methodology: a 30-year retrospective.

Clark, T. W. (2002). The policy process: A practical guide for natural resource professionals. *Yale University Press.*

De Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological economics*, *41*(3), 393-408.

Didham, R. K., Tylianakis, J. M., Gemmell, N. J., Rand, T. A., & Ewers, R. M. (2007). Interactive effects of habitat modification and species invasion on native species decline. *Trends in Ecology & Evolution*, *22*(9), 489-496.

Didham, R. K., Tylianakis, J. M., Hutchison, M. A., Ewers, R. M., & Gemmell, N. J. (2005). Are invasive species the drivers of ecological change?. *Trends in Ecology & Evolution*, *20*(9), 470-474.

Diersing, N. (2009). Water quality; frequently asked questions. PDA.NOAA. Retrieved from http://floridakeys.noaa.gov/scisummaries/wqfaq.pdf. Accessed on 7th September, 2016.

Ecosystem Based Adaptation to Climate Change in Seychelles (2013). Project Document. Ministry of Environment, Energy and Climate Change and United Nations Development Programme.

Edwards, P. J., Schoonover, J. E., & Williard, K. W. (2015). Guiding principles for management of forested, agricultural, and urban watersheds. *Journal of Contemporary Water Research & Education*, *154*(1), 60-84.

Environment Agency (2009). Water Resource Strategy for England and Wales. Environment Agency, Bristol, 92 pp.

Festinger, L. (1957). Cognitive dissonance theory. *1989) Primary Prevention of HIV/AIDS: Psychological Approaches. Newbury Park, California, Sage Publications*.

Fleischmann, K. (1997). Invasion of alien woody plants on the islands of Mahé and Silhouette, Seychelles. *Journal of Vegetation Science*, *8*(1), 5-12.

Fleischmann, K. (1997). Invasion of alien woody plants on the islands of Mahe and Silhouette, Seychelles. *Journal of Vegetation Science,* 8: 5-12.

Fleischmann, K. (1999). Relations between the invasive Cinnamomum verum and the endemic Phoenicophorium borsigianum on Mané island, Seychelles..*Applied Vegetation Science*, *2*(1), 37-46.

Fleischmann, K. (2016) in Gamatis I., Post-Restoration plant community on a mid-altitude glacis at Morn Blanc, Mahé: Does the native vegetation recover from disturbance? *B.Sc. Thesis University of Seychelles*

Fleischmann, K., Edwards, P. J., Ramseier, D., & Kollmann, J. (2005). Stand structure, species diversity and regeneration of an endemic palm forest on the Seychelles. *African Journal of Ecology*, *43*(4), 291-301.

Green, P. A., Vörösmarty, C. J., Harrison, I., Farrell, T., Sáenz, L., & Fekete, B. M. (2015). Freshwater ecosystem services supporting humans: Pivoting from water crisis to water solutions. *Global Environmental Change*, *34,* 108-118.

Gregersen, H. M., Ffolliott, P. F., & Brooks, K. N. (2007). Integrated watershed management: Connecting people to their land and water. CABI.

Hein, L., Van Koppen, K., De Groot, R. S., & Van Ierland, E. C. (2006). Spatial scales, stakeholders and the valuation of ecosystem services. *Ecological economics,* 57(2), 209-228.

Hellsten, S., Liquete, C., Forsius, M., Reynaud, A., Lanzanova, D., Cardoso, A. C., & Grizzetti, B. (2015). Cook-book for water ecosystem service assessment and valuation.

Hobbs, R. J., Higgs, E., & Harris, J. A. (2009). Novel ecosystems: implications for conservation and restoration. *Trends in ecology & evolution*, *24*(11), 599-605.

Huber, M. & Ismail, S. (2006). Suggested IUCN red list status of the endemic woody plants of the Inner Seychelles. *Master-Thesis, Institute of Integrative Biology Zurich, ETH, Zurich.*

INC (2000). Seychelles First National Communication to the United Nations Framework on Climate Change (UNFCCC). *Government of Seychelles, Seychelles.*

Jewitt, G. (2002). Can integrated water resources management sustain the provision of ecosystem goods and services? *Physics and Chemistry of the Earth, Parts A/B/C*, *27*(11), 887-895.

Katulic, S., Valentin, T., & Fleischmann, K. (2005). Invasion of creepers on the Island of Mahé, Seychelles. *Unpublished report, Geobotanical Institute, ETH Zurich, Switzerland & MENR, Seychelles*.

Kueffer, C., Beaver, K., & Mougal, J. (2013). Case Study: Management of Novel Ecosystems in the Seychelles. *Novel Ecosystems: Intervening in the New Ecological World Order*, 228-238.

Kueffer, C., Schumacher, E., Dietz, H., Fleischmann, K., & Edwards, P. J. (2010). Managing successional trajectories in alien-dominated, novel ecosystems by facilitating seedling regeneration: a case study. *Biological Conservation*, *143*(7), 1792-1802.

Meylan, G., Stauffacher, M., Krütli, P., Seidl, R., & Spoerri, A. (2015). Identifying Stakeholders' Views on the Eco-efficiency Assessment of a Municipal Solid Waste Management System. *Journal of Industrial Ecology*,*19*(3), 490-503.

Millennium Ecosystem Assessment (2005). "Ecosystems and human well-being: biodiversity synthesis." World Resources Institute, *Washington, DC.*

Parry, M. L. (Ed.). (2007). Climate change 2007-impacts, adaptation and vulnerability: Working group II contribution to the fourth assessment report of the IPCC (Vol. 4). *Cambridge University Press.*

Pati, D., Park, C. S., & Augenbroe, G. (2009). Roles of quantified expressions of building performance assessment in facility procurement and management. *Building and Environment*, *44*(4), 773-784.

Payet, R., & Agricole, W. (2006). Climate change in the Seychelles: implications for water and coral reefs. *AMBIO: A Journal of the Human Environment*, *35*(4), 182-189.

Ponette-Gonzalez, A. G., Brauman, K. A., Marín-Spiotta, E., Farley, K. A., Weathers, K. C., Young, K. R., & Curran, L. M. (2015). Managing water services in tropical regions: From land cover proxies to hydrologic fluxes. *Ambio*, *44*(5), 367-375.

Postel, S. L., & Thompson, B. H. (2005, May). Watershed protection: Capturing the benefits of nature's water supply services. In *Natural Resources Forum*(Vol. 29, No. 2, pp. 98-108). Blackwell Publishing, Ltd..

Price, K. (2011). Effects of watershed topography, soils, land use, and climate on baseflow hydrology in humid regions: A review. *Progress in physical geography*, *35*(4), 465-492.

Quayle, L., & Pringle, C. (2014). A guide for assessing ecosystem services at the catchment scale.

Ratcliffe, J., Stubbs, M., & Shepherd, M. (2004). Urban planning and real estate development (Vol. 8). Taylor & Francis.

Scholz, R. W., & Tietje, O. (2002). Embedded case study methods. Integrating quantitative and qualitative knowledge. *Thousand Oaks, London7 Sage*.

SENG, D. C., & GUILLANDE, R. (2008). Disaster risk profile of the Republic of Seychelles.

Seychelles National Climate Change Committee. (2011). Seychelles National Climate Change Strategy. Accessed April.

Seychelles Sustainable Development Strategie (2012-2010). Volume 2. Strategic Plans. Ministry of Environment & Energy.

Shahin, M. (2002). Hydrology and water resources of African islands.*Hydrology and water resources of Africa*, 565-582.

Srinivasan, V., Seto, K. C., Emerson, R., & Gorelick, S. M. (2013). The impact of urbanization on water vulnerability: a coupled human–environment system approach for Chennai, India. *Global Environmental Change*, *23*(1), 229-239.

Strayer, D. L., Eviner, V. T., Jeschke, J. M., & Pace, M. L. (2006). Understanding the long-term effects of species invasions. *Trends in ecology & evolution*, *21*(11), 645-651.

Tietje, O. (2005). Identification of a small reliable and efficient set of consistent scenarios. *European Journal of Operational Research*, *162*(2), 418-432.

Troch, P. A., Martinez, G. F., Pauwels, V., Durcik, M., Sivapalan, M., Harman, C., & Huxman, T. (2009). Climate and vegetation water use efficiency at catchment scales. *Hydrological Processes*, *23*(16), 2409-2414.

Vester, F. (2012). The art of interconnected thinking: ideas and tools for a new approach to tackling complexity. BoD–Books on Demand.

Wallace, K. J. (2007). Classification of ecosystem services: problems and solutions. *Biological conservation*, *139*(3), 235-246.

Waring, R. H., & Running, S. W. (2010). Forest ecosystems: analysis at multiple scales. Elsevier.

Weatherhead, E. K., & Howden, N. J. K. (2009). The relationship between land use and surface water resources in the UK. *Land Use Policy*, *26*, S243-S250.

Yamamoto, T., & Anderson, H. W. (1967). Erodibility indices for wildland soils of Oahu, Hawaii, as related to soil forming factors. *Water Resources Research*,*3*(3), 785-798.

F2 List of figures

F3 List of tables

Table D16: One-Way ANOVA results for *Farming development* among the stakeholders for each scenario.

Table D17: One-Way ANOVA results for *Environmental protection* among the stakeholders for each scenario.

Table D18: One-Way ANOVA results for *Retention capacity and flood protection* among the stakeholders for each scenario.

G. Appendixes

G1 Questionnaire

STÉPHANIE MASSY AND MÉLANIE SCHMUTZ

Swiss Federal Institute of Technology (ETH), Zürich, Switzerland

Department of Environmental Systems Science (D-USYS), Transdisciplinarity Lab (TdLab)

Supervisor: Dr. Pius Krütli, TdLab, pius.kruetli@usys.ethz.ch

Co-Supervisor: Dr. Karl Fleischmann, University of Seychelles, Karl@unisey.ac.sc

Ecosystem Based Adaptation project

Please fill in:

Age: ________________________________

Work position: ________________________________

Agency: ________________________________

Place of residence: ________________________________

*Please be aware that even if you are not living in the Val d'Endor you can take this survey as we are looking at how people feel about the issues relating to water, you do not need to have knowledge on the area to do this questionnaire.

Description of our project

We are two students from Switzerland doing our Master thesis in the Seychelles. We are working here with the PCU (Programme Coordination Unit) on the first component of the EbA (Ecosystem based Adaptation) project, which takes two broad approaches to improving water security. The first is to improve water storage of both rivers and wetlands by enhancing river functions. The second is the rehabilitation of catchment forest.

For our Master thesis, we want to investigate what the current state of the Val d'Endor water catchment areas is. This includes the analysis of (1) the quality of the vegetation, and (2) human impacts focusing on freshwater provision. We want to analyse how the current situation in Val d'Endor watershed is and identify the type of tradeoffs between water provision and other activities (housing, infrastructure, water management (i.e. provision, treatment, pollution and land use) in the area. This particular assessment is a survey with the EbA project in collaboration with ETH Zürich and UniSey. Results are expected to inform decision makers about the current state of water catchment areas, the perceptions people have of the different ecosystem services in the catchment area and the potential trade-offs of competing use. It might also lead to a proper management of the Val d'Endor water catchment.

Description of this questionnaire

In this questionnaire, you will find four simple scenarios (recap on p.15), based on the variation of 11 impact variables (see list below, p.2) that have a great impact on freshwater supply and retention, which explain what the situation in the Val d'Endor watershed could be in 30 years. Another scenario represents the current situation (scenario 0). We will also give you 5 different criteria (see list below, p.2) to assess the different scenarios.

In this questionnaire we will ask you:

- **Step 1**: rate the 5 different criteria from 1 (not important to you) to 7 (very important to you) and explain to us why you choose this rate.

According to the current situation you will be asked:

- **Step 2:** rate how well each criterion performs from 1 (bad performance) to 7 (high performance).

According to the description of the 4 scenarios, you will be asked:

- **Step 3:** rate each scenario according to your first impression, how desirable the scenario is to you and then how probable the scenario is likely to happen.
- **Step 4:** rate how happy you are towards each criterion compared to the current state scenario (scenario 0).
- **Step 5:** answer to a few questions.

The time estimated for this questionnaire is 40 minutes.

Impact variables

1. **Farming** (it refers to the total area used for agricultural purposes in Val d'Endor, to the distribution of agricultural land in Val d'Endor and to agricultural intensification)
2. **Legal context** (specific policies, legislation and regulations regarding water quality, water abstraction, water catchment area protection, farming activities and housing close to rivers, and littering)
3. **Law enforcement** (It refers to an official bodies who discover, identify and punish people who break the laws and regulations)
4. **Sanitation system** (kind of sanitation system present in the Baie Lazare water catchment (i.e. septic tanks and soak away pits) and overflowing of sewage)
5. **Housing** (number of houses and buildings, and the total area for housing in Val d'Endor)
6. **Water storage infrastructure** (infrastructure used for water storage such as PUC barrages, Seychelles Agricultural Agency (SAA) barrages, barrages constructed by residents and farmers, wells, distribution tanks (PUC) and private water tanks (farmers and residents))
7. **Agricultural by-product** (runoff and leaching of pesticides and fertilizers, erosion and sediment from cultivation, improper disposal of animal's faeces and dead animals)
8. **Extent of forest** (total area of forest in Baie Lazare watershed)
9. **Water abstraction** (where, how and how much water is abstracted in Val d'Endor)
10. **Weather** (This external variable refers to the daily rainfall as well as the mean daily temperature. It is predicted that annual rainfall will increase by 3-5% by 2050 which will ultimately causes more flooding, in case of drought period they will be longer, the annual temperature will increase by 2.1°C by 2100)
11. **Drainage** (natural or artificial removal of surface and sub-surface water from an area)

Criteria

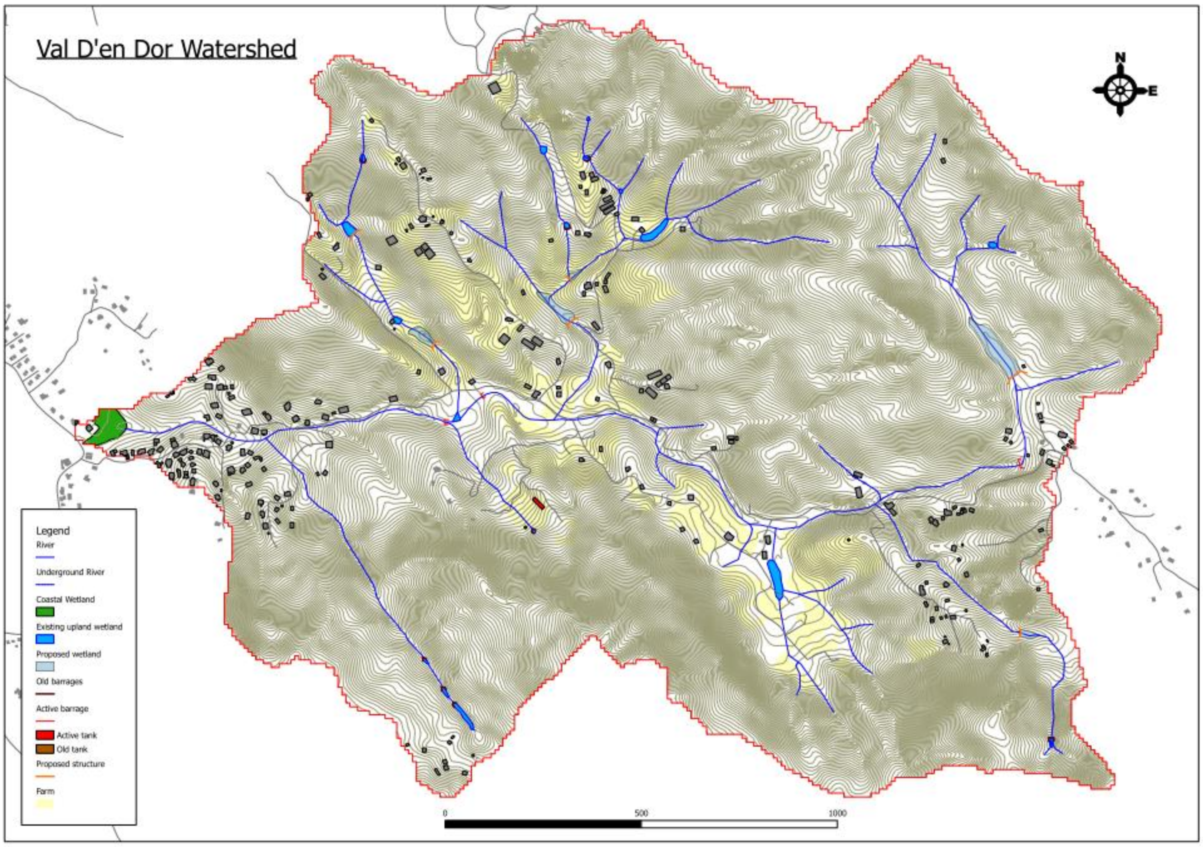
1. **Water supply**
   It refers to the availability and quality of water throughout the year within the Baie Lazare River.
2. **Housing and infrastructure**
   It refers to the development of housing, infrastructures (hospitals, schools, official buildings, shops, etc.), roads, etc. in Baie Lazare water catchment.
3. **Farming development**
   It refers to the development of farming activities and area in Baie Lazare water catchment.
4. **Environmental protection**
   It refers to the protection of the Baie Lazare water catchment (forest and river)
5. **Retention capacity and flood protection**
   It refers to the water retention capacity of the ground in Baie Lazare watershed (as forest infiltration and slows runoff in a watershed, buildings and constructions will reduce the water retention capacity and increase run-off of an area). Reducing the retention capacity will ultimately increase the risk of flooding.

<u>Criteria importance assessment</u> (circle your choice)

Please rate each criterion from 1 (not important to you) to 7 (very important to you) and explain why the criteria is not, a little or very important to you (for example, you have to ask yourself, is water supply important for me? And how important is it? Do the same for each criterion)

Water supply	1 not at all important	2	3	4	5	6	7 very important	why: ______________ ____________________ ____________________ ____________________
Housing and infrastructure	1 not at all important	2	3	4	5	6	7 very important	why: ______________ ____________________ ____________________ ____________________
Farming development	1 not at all important	2	3	4	5	6	7 very important	why: ______________ ____________________ ____________________ ____________________
Environmental protection	1 not at all important	2	3	4	5	6	7 very important	why: ______________ ____________________ ____________________ ____________________
Retention capacity and flood protection	1 not at all important	2	3	4	5	6	7 very important	why: ______________ ____________________ ____________________

Scenario 0 “Current State”



Current state scenario
This scenario represents the current situation in Val d’Endor watershed (in 2016). The area of the water catchment is principally dedicated to agriculture. Fertilizers and pesticides are sometimes used for crops. Some livestock, such as cows, pigs and poultry are present in the area. There is thus possibility of polluting the water of Baie Lazare River from agricultural activities and livestock production. For irrigation purposes, the water is abstracted from PUC barrages, from Seychelles Agricultural Agency barrages, or comes from legal or illegal abstraction of water directly from the river by residents and farmers. In addition, people living in the area usually have as well private water tanks and wells. The abstraction of water (its volume) is not controlled. The laws and regulations about water abstraction in terms of volume are non-existent. Some laws exist about water quality, but no laws about protection of watershed. On the other hand, laws about the type of pesticides that can be used exist. In general, the law is poorly enforced, because of lack of staff. In Val d’Endor watershed, some areas are dedicated to housing. Each house has a septic tank. The houses are supposed to be at least 15 meters away from the river to prevent pollution of the water course. For household purposes, inhabitants in the area use water from PUC system or use water from their own wells or own piping system. No laws about the protection of the forest exist, but the trees are themselves protected. People need to ask permission for felling trees. There is no drainage in Val d’Endor watershed. Climate is slowly changing and shifting (more precipitation, more flooding, longer drought period).

Criteria performance’s assessment (circle your choice)

Please rate how well performs each criterion in the current state scenario (meaning in the present).

Water supply yourself quality of the	1 very bad water supply	2	3	4	5	6	7 very good water supply	**(Here you have to ask how you rate the water supply in Val d’Endor)**
Housing and infrastructure	1 low development	2	3	4	5	6	7 high development	**(Here you have to ask yourself how you rate of housing and infr infrastructure in Val d’Endor**
Farming development	1 very low farming	2	3	4	5	6	7 very high farming	**(Here you have to ask how you rate the development of farming in Val d’Endor.**
Environmental protection	1 low environmental protection	2	3	4	5	6	7 very high environmental protection	**(Here you have how you rate the protection of water catchment (forest, river)**
Retention capacity and flood retention	1 very low retention	2	3	4	5	6	7 very high retention	**(Here you have to ask how you rate retention capacity in Val d’Endor)**

Scenario 1 “Intensive Housing”

Intensive housing

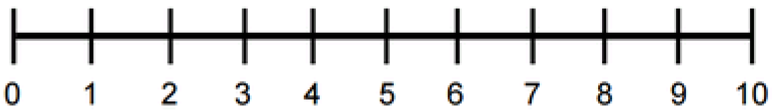
In this first scenario, the number of houses and the area dedicated to housing in Val d’Endor watershed has increased. This means that the population of Val d’Endor has also increased. In this context, there is an increase in the number of septic tanks, which ultimately cause more pollution due to overflow of sewage. Given the increase in population, more water is abstracted from Baie Lazare River for household purposes. As a result, the number of wells and private water tanks increase. As a consequence of increased housing, the farming area will decrease and farming activities will decrease too. It means that agricultural pollution such as pesticides, fertilizers, and animal’s excrements will decrease. As the area for housing increases, the area of the forest decreases.

There will be no change compared to the current situation about the legal context and law enforcement. It means that the specific policies, legislation and regulations regarding water quality, water abstraction, water catchment area protection, farming activities, housing, as well as littering are the same as the situation at hand. The same goes for law enforcement. Drainage will stay the same as the current situation. Climate change will also have its impact on the watershed (more precipitation, more flooding, longer drought period).

Recap scenario 1

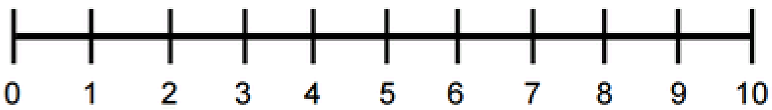
Impact variables	Status (compared to current situation)	Description
Farming area	decrease	-
Agricultural by-product	decrease	because of less farming
Housing	increase	more houses and roads
Sanitation system	increase	more septic tanks and more pollution due to overflow of sewage
Water storage infrastructure	increase	more wells and private tanks
Water abstraction	increase	more water is abstracted for household purposes
Extent of forest	decrease	because of increasing housing area
Legal context	no change	-
Law enforcement	no change	-
Drainage	no change	no artificial drainage system
Weather	shift due to climate change	increased precipitation (more flooding), increased temperature, longer drought period.

Desirability of this scenario (insert a cross on the scale)



not desirable — highly desirable — **(rate how much you would like to see this scenario happen)**

Probability of this scenario in 30 years (insert a cross on the scale)



not probable — highly probable — **(rate how probable this scenario could happen)**

<u>Criteria desirability's assessment</u> (circle your choice)

Please rate how happy you are towards each criterion in this scenario compared to the current state scenario.

1. You have to ask yourself if the status of the water supply in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of the water supply in this scenario compared to now.**

Water supply	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**
	Much less happy	less happy	slightly less happy	as happy as now	slightly more happy	more happy	much more happy

---

2. You have to ask yourself if the status of the housing and infrastructure in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of housing and infrastructure in this scenario compared to now.** (For example in scenario 1, housing has increased, so are you more or less happy about that situation than the current situation of housing in Val d'Endor)

Housing and infrastructure	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**
	Much less happy	less happy	slightly less happy	as happy as now	slightly more happy	more happy	much more happy

---

3. You have to ask yourself if the status of the farming development in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of farming development in this scenario compared to now.**

Farming development	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**
	Much less happy	less happy	slightly less happy	as happy as now	slightly more happy	more happy	much more happy

---

4. You have to ask yourself if the status of the environmental protection in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of the environmental protection in this scenario compared to now.**

Environmental protection	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**
	Much less happy	less happy	slightly less happy	as happy as now	slightly more happy	more happy	much more happy

---

5. You have to ask yourself if the status of the water retention capacity in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of the water retention capacity in this scenario compared to now.**

Water retention capacity and Flood retention	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**
	Much less happy	less happy	slightly less happy	as happy as now	slightly more happy	more happy	much more happy

Scenario 2 “Increased Farming”

Increased farming

In the second scenario, the farming area and the farming activities such as crops and livestock has increased in Val d’Endor. As a consequence, the agricultural pollution caused by pesticides, fertilizers and animal excrement has increased. The farming activities will tend to be more intensive (industrialized). As the farming activities are intensified, more water is abstracted from the Baie Lazare River for the irrigation of crops and water for animals. The number of wells, private water tanks and barrages increase in order to have a better water storage for agricultural purposes. As the area for farming increases, the area of the forest decreases.

On the other hand, the number of houses and thus the number of septic tanks remain constant. There will be no change compared to the current situation about the legal context and law enforcement. Drainage will stay the same as the current situation. Climate change will also have its impact on the watershed (more precipitation, more flooding, longer drought period).

Recap of scenario 2

Impact variables	**Status (compared to current situation)**	**Description**
Farming area	increase	more intensive farming (industrialised)
Agricultural by-product	increase	because of more farming
Housing	no change	-
Sanitation system	no change	same system, septic tanks
Water storage infrastructure	increase	more private tanks and barrages for farming
Water abstraction	increase	more water is abstracted for irrigation
Extent of forest	decrease	because of increasing farming area
Legal context	no change	-
Law enforcement	no change	-
Drainage	no change	no artificial drainage system
Weather	shift due to climate change	increased precipitation (more flooding), increased temperature, longer drought period.

Desirability of this scenario (insert a cross on the scale)

0 1 2 3 4 5 6 7 8 9 10

not desirable — highly desirable

(rate how much you would like to see this scenario happen)

Probability of this scenario in 30 years (insert a cross on the scale)

0 1 2 3 4 5 6 7 8 9 10

not probable — highly probable

(rate how probable this scenario could happen)

Criteria desirability’s assessment (circle your choice)

Please rate how happy you are towards each criterion in this scenario compared to the current state scenario.

1. You have to ask yourself if the status of the water supply in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of the water supply in this scenario compared to now.**

Water supply	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**
	Much less happy	less happy	slightly less happy	as happy as now	slightly more happy	more happy	much more happy

---

2. You have to ask yourself if the status of the housing and infrastructure in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of housing and infrastructure in this scenario compared to now.** (For example in scenario 1, housing has increased, so are you more or less happy about that situation than the current situation of housing in Val d’Endor)

Housing and infrastructure	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**
	Much less happy	less happy	slightly less happy	as happy as now	slightly more happy	more happy	much more happy

---

3. You have to ask yourself if the status of the farming development in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of farming development in this scenario compared to now.**

Farming development	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**
	Much less happy	less happy	slightly less happy	as happy as now	slightly more happy	more happy	much more happy

---

4. You have to ask yourself if the status of the environmental protection in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of the environmental protection in this scenario compared to now.**

Environmental protection	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**
	Much less happy	less happy	slightly less happy	as happy as now	slightly more happy	more happy	much more happy

---

5. You have to ask yourself if the status of the water retention capacity in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of the water retention capacity in this scenario compared to now.**

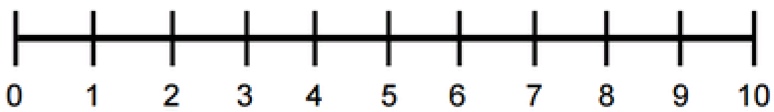
Water retention capacity and Flood retention	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**
	Much less happy	less happy	slightly less happy	as happy as now	slightly more happy	more happy	much more happy

Scenario 3 “Better protected water catchment”

Better protected water catchment
In this third scenario, the state of the Val d’Endor remains the same as it is today. It means that farming area and activities, housing, sewage system, size of the forest, storage infrastructures stay as the current situation (scenario 0). But the legislation is tougher. Specific board will be implemented to control water abstraction from Baie Lazare River and to regulate it. Thus, the abstraction of water is much more regulated in order to have a sustainable water supply throughout the year. So, the amount of water abstracted for irrigation and household purposes will probably decrease. This scenario also comprises better protection of the watershed in general such as forest protection, river protection by avoiding pollution and contamination. There will be strict laws on how to use pesticides and fertilizers in order to reduce to a maximum its impact on the environment. Also, there will be an increase of regulations for the disposal of animal excrement (proper container, far from rivers). Law enforcement will follow the same trend by increasing control and by taking actions in case of trespassing. This scenario is eco-oriented in order to protect the watershed a maximum and minimise the impacts of human on the environment (water, forest). Climate change will also have its impact on the watershed (more precipitation, more flooding, longer drought period). The drainage system will be better managed to mitigate the effect of flooding and erosion.

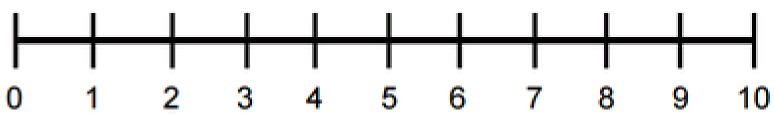
Recap of scenario 3		
Impact variables	**Status (compared to current situation)**	**Description**
Farming area	no change	-
Agricultural by-product	decrease	because of more laws
Housing	no change	-
Sanitation system	no change	same system, septic tanks
Water storage infrastructure	no change	-
Water abstraction	no change	better management
Extent of forest	no change	-
Legal context	increase	more laws and regulations
Law enforcement	increase	more controls
Drainage	increase	creation of artificial drainage system
Weather	shift due to climate change	increased precipitation (more flooding), increased temperature, longer drought period.

Desirability of this scenario (insert a cross on the scale)



not desirable | highly desirable | **(rate how much you would like to see this scenario happen)**

Probability of this scenario in 30 years (insert a cross on the scale)



not probable | highly probable | **(rate how probable this scenario could happen)**

<u>Criteria desirability's assessment</u> (circle your choice)

Please rate how happy you are towards each criterion in this scenario compared to the current state scenario.

1. You have to ask yourself if the status of the water supply in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of the water supply in this scenario compared to now.**

Water supply	**-3** Much less happy	**-2** less happy	**-1** slightly less happy	**0** as happy as now	**1** slightly more happy	**2** more happy	**3** much more happy

---

2. You have to ask yourself if the status of the housing and infrastructure in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of housing and infrastructure in this scenario compared to now.** (For example in scenario 1, housing has increased, so are you more or less happy about that situation than the current situation of housing in Val d'Endor)

Housing and infrastructure	**-3** Much less happy	**-2** less happy	**-1** slightly less happy	**0** as happy as now	**1** slightly more happy	**2** more happy	**3** much more happy

---

3. You have to ask yourself if the status of the farming development in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of farming development in this scenario compared to now.**

Farming development	**-3** Much less happy	**-2** less happy	**-1** slightly less happy	**0** as happy as now	**1** slightly more happy	**2** more happy	**3** much more happy

---

4. You have to ask yourself if the status of the environmental protection in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of the environmental protection in this scenario compared to now.**

Environmental protection	**-3** Much less happy	**-2** less happy	**-1** slightly less happy	**0** as happy as now	**1** slightly more happy	**2** more happy	**3** much more happy

---

5. You have to ask yourself if the status of the water retention capacity in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of the water retention capacity in this scenario compared to now.**

Water retention capacity and Flood retention	**-3** Much less happy	**-2** less happy	**-1** slightly less happy	**0** as happy as now	**1** slightly more happy	**2** more happy	**3** much more happy

Scenario 4 “Better regulated intensification of farming and housing”

Better regulated intensification of farming and housing

In this fourth scenario, the farming area and farming activities such as crops and livestock has increased in Val d’Endor. Since the legislations and law enforcement are tougher, the agricultural pollution from pesticides, fertilizers and animal excrement will decrease. Furthermore, the number of houses and the area dedicated to housing in Val d’Endor watershed increase as well. The increase of farming and housing is though limited by the laws and legislations which are tougher and will be made to protect the forest and rivers in the watershed. The intensification of housing will take place in area where housings are already present and the same for farming. This general increase will obviously slow down after a while as the legal context will not allow the infinite extension of farming and housing. Given the general increase of farming and housing, the size of the forest decreases a bit (but still protected by legislations), but some area of the forest will be completely protected (for example area where native species are highly present).
As a consequence of this increase, two alternatives are possible concerning sewerage: a centralized sewerage system or better-managed septic tank system (no overflow and no pollution of surface water). Moreover, more water is abstracted from the Baie Lazare River because of the increase of population and farming (but it will be highly regulated). Also, the number of wells, private water tanks and barrages increase in order to have a better storage of water. Climate change will also have its impact on the watershed (more precipitation, more flooding, longer drought period). The drainage system will be better managed to mitigate the effect of flooding and erosion.

Recap of scenario 4

Impact variables	**Status (compared to current situation)**	**Description**
Farming area	increase	more farming activities
Agricultural by-product	increase	because of more farming
Housing	increase	more houses and roads
Sanitation system	increase	better managed septic tanks or linked sewerage
Water storage infrastructure	increase	more wells, private tanks and barrages
Water abstraction	increase	more water is abstracted for farming and household purposes
Extent of forest	decrease	because of increasing farming and housing area
Legal context	increase	more laws and regulations
Law enforcement	increase	more controls
Drainage	increase	creation of artificial drainage system
Weather	shift due to climate change	increased precipitation (more flooding), increased temperature, longer drought period.

Desirability of this scenario (insert a cross on the scale)

0 1 2 3 4 5 6 7 8 9 10

not desirable — highly desirable — **(rate how much you would like to see this scenario happen)**

Probability of this scenario in 30 years (insert a cross on the scale)

0 1 2 3 4 5 6 7 8 9 10

not probable — highly probable — **(rate how probable this scenario could happen)**

<u>Criteria desirability's assessment</u> (circle your choice)

Please rate how happy you are towards each criterion in this scenario compared to the current state scenario.

1. You have to ask yourself if the status of the water supply in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of the water supply in this scenario compared to now.**

Water supply	**-3** Much less happy	**-2** less happy	**-1** slightly less happy	**0** as happy as now	**1** slightly more happy	**2** more happy	**3** much more happy

---

2. You have to ask yourself if the status of the housing and infrastructure in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of housing and infrastructure in this scenario compared to now.** (For example in scenario 1, housing has increased, so are you more or less happy about that situation than the current situation of housing in Val d'Endor)

Housing and infrastructure	**-3** Much less happy	**-2** less happy	**-1** slightly less happy	**0** as happy as now	**1** slightly more happy	**2** more happy	**3** much more happy

---

3. You have to ask yourself if the status of the farming development in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of farming development in this scenario compared to now.**

Farming development	**-3** Much less happy	**-2** less happy	**-1** slightly less happy	**0** as happy as now	**1** slightly more happy	**2** more happy	**3** much more happy

---

4. You have to ask yourself if the status of the environmental protection in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of the environmental protection in this scenario compared to now.**

Environmental protection	**-3** Much less happy	**-2** less happy	**-1** slightly less happy	**0** as happy as now	**1** slightly more happy	**2** more happy	**3** much more happy

---

5. You have to ask yourself if the status of the water retention capacity in this scenario is more desirable or less desirable than in the scenario 0. **Meaning, are you more or less happy with the state of the water retention capacity in this scenario compared to now.**

Water retention capacity and Flood retention	**-3** Much less happy	**-2** less happy	**-1** slightly less happy	**0** as happy as now	**1** slightly more happy	**2** more happy	**3** much more happy

General questions

Do you have concern about water catchment? If yes, what are they?

____

____

____

____

____

____

Is water provision an issue for you? Do you think it will be a problem in the future?

____

____

____

____

____

____

What do you think about the quality of the water in Val d'Endor? (taste, treatment, pollution, etc.)

____

____

____

____

____

____

How do you see the future in Val d'Endor (concerning housing, farming and water supply)?

____

____

____

____

Recap of the scenarios compared to the current state scenario

	Scenario 1 « Intensive housing »	Scenario 2 « Increased farming »	Scenario 3 « Better protected water catchment »	Scenario 4 « Better regulated intensification of farming and housing »
Farming area	decrease	increase	no change	increase
Agricultural by-product	decrease	increase	decrease	increase
Housing	increase	no change	no change	increase
Sanitation system	increase	no change	no change	increase
Water storage infrastructure	increase	increase	no change	increase
Water abstraction	increase	increase	no change	increase
Extent of forest	decrease	decrease	no change	decrease
Legal context	no change	no change	increase	increase
Law enforcement	no change	no change	increase	increase
Drainage	no change	no change	increase	increase
Weather	shift due to climate change	shift due to climate change	shift due to climate change	shift due to climate change

G2 Tables

Table G1: GPS Coordinates for each transect. The coordinates for each beacon (0m to 200m) are shown.

Transects	Distance (m)	GPS Coordinates	
		UTM S40 - X	UTM S40 - Y
1	0	334615	9472903
	50	334616	9472860
	100	334619	9472802
	150	334604	9472752
	200	334655	9472787
2	0	333972	9472867
	50	334003	9472809
	100	334005	9472770
	150	334018	9472717
	200	334016	9472776
3	0	334285	9474087
	50	334309	9474076
	100	334348	9474027
	150	334381	9474075
	200	334402	9474109
4	0	333032	9472878
	50	333091	9472928
	100	333053	9472961
	150A	333025	9472988
	150B	333056	9472980
	200	333007	9473026
5	0	332967	9473080
	50	332946	9473126
	100	332907	9473183
	150	332882	9473218
	200	332874	9473255
6	0	334189	9472936
	50	334216	9472911
	100	334210	9472856
	150	334230	9472801
	200	334203	9472765
7	0	333381	9473225
	50	333406	9473161
	100	333456	9473194
	150	333477	9473177
	200	333516	9473197
8	0	333714	9474173
	50	333758	9474201
	100	333792	9474221
	150	333797	9474199
	200	333837	9474163
9	0	333878	9474065
	50	333930	9474108
	100	333981	9474092
	150	334048	9474081
	200	334052	9474116
10	0	334386	9474161
	50	334366	9474202
	100	334401	9474250
	150	334435	9474274
	200	334440	9474286

Table G2: GPS Coordinates for each permanent plot.

Transects	Beacons	GPS Coordinates	
		UTM S40 - X	UTM S40 - Y
1	PPB1 PPB2	334630 334619	9472796 9472802
2	PPB1 PPB2	333992 334005	9472776 9472795
3	PPB1 PPB2	334285 334283	9474087 9474076
4	PPB1 PPB2	333021 333007	9473006 9473026
5	PPB1 PPB2	332846 332802	9473293 9473295
6	PPB1 PPB2	334213 334230	9472937 9472933
7	PPB1 PPB2	333489 333512	9473172 9473186
8	PPB1 PPB2	333748 333736	9474204 9474190
9	PPB1 PPB2	333898 333870	9474072 9474072
10	PPB1 PPB2	334391 334380	9474158 9474174

Table G3: List of tree species (37 species, 32 adults and 24 saplings) in the 10 transects in the Val d'Endor watershed.
Note: This table gives the latin species name, family, local name, origin (ind. = indigenous; exo. = exotic; end. = endemic ; "?" = origin not certified), IUCN-status (NA = taxon has not yet been assessed for the IUCN Red List ; LC = Least Concerned; VU = Vulnerable; NT = Near Threatened; DD = Data Deficient), PV = Prominent Value.

Latin species name	Family	Local name	origin	IUCN-status	PV of adults	PV of saplings
Adenanthera pavonina	Mimosaceae	Latagi	Exo.?	NA	11.81	14.86
Alstonia m.	Apocynyceae	Bwazonn	Exo.	LC	6.07	-
Arthocarpus altilis	Moraceae	Friyapen	Exo.	NA	3.36	2.96
Arthocarpus heterophyllus	Moraceae	Zak	Exo.	NA	1.19	-
Bambusa vulgaris	Poaceae	-	Exo.	NA	3.36	-
Barringtonia racemosa	Lecythidaceae	Bonnenkaredrivyer	Ind.	NA	-	1.31
Calophyllum inophyllum	Clusiaceae	Takamaka	Ind.	LC	2.39	1.31
Cananga odorata	Myristicaceae	Ilangilang	Exo.	NA	1.19	-
Casuarina equisetifolia	Casuarinacea	Sed	Exo.	NA	2.39	-
Chrysobalanus icaco	Chrysobalanaceae	Prindefrans	Exo.	NA	20.02	24.67
Cinnamomum verum	Lauraceae	Kannel	Exo.	NA	26.50	19.57
Cocos nucifera	Arecaceae	Koko	Ind.	NA	-	2.62
Deckenia nobilis	Arecaceae	Palmis	End.	VU	6.07	6.31
Diospyros boiviniana	Ebenaceae	Bwasagay	End.?	NT	5.52	3.64
Dracaena reflexa var. angustifolia	Liliaceae	Bwasandel	Ind.	NA	5.10	10.88
Euphorbia pyrifolia	Euphorbiaceae	Bwadile	Ind.	NA	1.19	-
Falcataria moluccana	Mimosaceae	Albizya	Exo.	NA	6.71	1.31
Ficus lutea	Moraceae	Lafous gran fey	Ind.	NA	1.19	-
Flacourtia cataphracta	Flacourtiaceae	Prin dipei	Exo.	NA	1.52	-
Hevea brasiliensis	Euphorbiaceae	Karoutsou	Exo.	NA	5.30	4.32
Mangifera indica	Anacardiaceae	Mang	Exo.	DD	1.19	-
Memecylon caeruleum	Melastomataceae	Bwademon	Exo.	NA	-	1.31
Memecylon elaeagni	Melastomataceae	Bwakalou	End.	LC	8.23	10.30
Nephrosperma vanhoutteanum	Arecaceae	Latannyen milpat	End.	LC	6.39	20.59
Ochna kirkii	Ochnaceae	Bwakok	Exo.	NA	7.26	15.88
Pandanus utilis	Pandanaceae	Vakwa sak	Exo.	NA	1.19	-
Paragenipa l.	Rubiaceae	Kafe maron gran fey	End.	NA	6.61	5.92
Phoenicophorium borsigianum	Arecaceae	Latannyen fey	End.	LC	16.02	28.76
Psidium cattleianum	Myrtaceae	Gouyavdesin	Exo.	NA	2.39	-
Pyrostria bibracteata	Rubiaceae	Bwadir rouz	Ind.	NA	1.19	2.62
Roscheria melanochaetes	Arecaceae	Latannyen oban	End.	NT	-	1.31
Sandoricum koetjape	Meliaceae	Santol	Exo.	NA	11.04	11.32
Syzigium aromaticum	Myrtaceae	Zerof	Exo.	NA	-	1.31
Tabebuia pallida	Bignoniaceae	Kalisdipap	Exo.	NA	20.99	3.93
Terminalia catappa	Combretaceae	Bodanmyen	Ind.?	NA	2.39	-
Verschaffeltia splendida	Arecaceae	Latannyen lat	End.	NT	1.19	-
Vitex doniana	Lamiaceae	-	Exo.	NA	3.03	2.96

Table G4: Rel. abundance (%) of adult and juvenile (i.e. saplings) tree species in *Dan Merl* transect.
Note: The purple names stand for endemic species, blue for indigenous species, black for exotic species.

Species of Dan Merl transect	Rel. abundance adults	Rel. abundance saplings	Other species in the area
Adenanthera p.	4	2	*Eucalyptus c.*
Arthocarpus a.	5	0	*Ochna k.*
Bambusa v.	10	0	*Canophyllum i.*
Chrysobalanus i.	5	21	*Arthocarpus h.*
Cinnamomum v.	37	10	*Citrus sp.*
Deckenia n.	1	0	*Mangifera i*
Dracaena r.	1	2	*Paragenipa l.*
Falcataria m.	0	1	*Psidium c.*
Memecylon e.	1	0	*Pyrostria b.*
Nephrosperma v.	2	7	
Phoenicophorium b.	17	44	
Psidium c.	1	0	
Sandoricum k.	9	10	
Tabebuia p.	3	1	
Terminalia c.	1	0	
Vitex d.	3	2	

Table G5: Rel. abundance (%) of adult and juvenile (i.e. saplings) tree species in *Dan Karolin west* transect.
Note: The purple names stand for endemic species, blue for indigenous species, black for exotic species.

Species of Dan Karolin west transect	Rel. abundance adults	Rel. abundance saplings	Other species in the area
Casuarina e.	1	0	*Syzygium a.*
Chrysobalanus i.	10	25	*Flacourtia c.*
Cinnamomum v.	31	13	*Diospyros b.*
Memecylon c.	0	1	*Adenanthera p.*
Memecylon e.	6	25	*Aphloia t.*
Nephrosperma v.	0	11	*Arthocarpus a.*
Ochna k.	0	2	*Arthocarpus h.*
Paragenipa l.	0	2	*Bambusa v.*
Phoenicophorium b.	5	20	*Callophylum i.*
Tabebuia p.	47	1	*Ceiba p.*
			Citrus sp.
			Deckenia n.
			Dracaena r.
			Erythroxylum s.
			Falcataria m.
			Flacourtia i.
			Lantana c.
			Diospyros b.
			Mangifera i.
			Psidium c.
			Pyrostria b.
			Arthocarpus o.
			Sandoricum k.
			Syzygium a.
			Vitex d.

Table G6: Rel. abundance (%) of adult and juvenile (i.e. saplings) tree species in *Dan Tombalo low* transect.
Note: The purple names stand for endemic species, blue for indigenous species, black for exotic species.

Species of Dan Tombalo low transect	Rel. abundance adults	Rel. abundance saplings	Other species in the area
Cinnamomum v.	56	14	*Arthocarpus a.*
Bambusa v.	1	0	*Arthocarpus h.*
Casuarina e.	1	0	*Citrus sp.*
Chrysobalanus i.	5	30	*Deckenia n.*
Adenanthera p.	2	14	*Dodonea v.*
Pyrostria b.	0	1	*Hevea b.*
Phoenicophorium b.	0	29	*Leucaena l.*
Dracaena r.	0	7	*Ludia m. var s.*
Alstonia m.	6	0	*Mangifera i.*
Falcataria m.	3	0	*Paragenipa l.*
Nephrosperma v.	0	4	*Syzygium a.*
Ochna k.	0	1	*Vitex d.*
Psidium c.	1	0	
Tabebuia p.	25	0	

Table G7: Rel. abundance (%) of adult and juvenile (i.e. saplings) tree species in *Dan Pinpin up* transect.
Note: The purple names stand for endemic species, blue for indigenous species, black for exotic species.

Species of Dan Pinpin up transect	Rel. abundance adults	Rel. abundance saplings	Other species in the area
Adenanthera p.	1	6	*Dracaena r.*
Arthocarpus a.	2	2	*Memecylon e.*
Chrysobalanus i.	8	5	*Arthocarpus h.*
Cinnamomum v.	30	4	*Epipremnum a.*
Deckenia n.	1	6	*Flacourtia i.*
Euphorbia p.	1	0	*Garcinia m.*
Flacourtia c.	2	0	*Heritiera l.*
Hevea b.	39	18	*Mangifera i.*
Nephrosperma v.	0	2	*Peponidium c.*
Ochna k.	2	7	*Psidium c.*
Pandanus u.	1	0	*Pyrostria b.*
Phoenicophorium b.	1	39	*Rhipasils b.*
Sandoricum k.	11	11	*Vanilla p.*
Tabebuia p.	1	0	

Table G8: Rel. abundance (%) of adult and juvenile (i.e. saplings) tree species in *Dan Pinpin low* transect.
Note: The purple names stand for endemic species, blue for indigenous species, black for exotic species.

Species of Dan Pinpin low transect	Rel. abundance adults	Rel. abundance saplings	Other species in the area
Adenanthera p.	2	1	*Psidium c.*
Arthocarpus h.	1	0	
Chrysobalanus i.	11	9	
Cinnamomum v.	34	5	
Deckenia n.	12	18	
Dracaena r.	1	1	
Hevea b.	25	4	
Nephrosperma v.	2	4	
Ochna k.	1	8	
Paragenipa l.	0	1	
Phoenicophorium b.	10	47	
Sandoricum k.	0	2	
Tabebuia p.	1	0	

Table G9: Rel. abundance (%) of adult and juvenile (i.e. saplings) tree species in *Dan Karolin east* transect.
Note: The purple names stand for endemic species, blue for indigenous species, black for exotic species.

Species of Dan Karolin east transect	Rel. abundance adults	Rel. abundance saplings	Other species in the area
Adenanthera p.	6	3	*Curculigo r.*
Alstonia m.	1	0	*Arthocarpus h.*
Arthocarpus a.	0	1	*Dracaena r.*
Calophyllum i.	1	0	*Deckenia n.*
Chrysobalanus i.	6	13	
Cinnamomum v.	36	1	
Cocos n.	0	1	
Diospyros b.	5	2	
Falcataria m.	6	0	
Memecylon e.	7	1	
Nephrosperma v.	3	16	
Ochna k.	0	6	
Paragenipa l.	1	0	
Phoenicophorium b.	10	55	
Sandoricum k.	1	0	
Syzygium a.	0	1	
Tabebuia p.	17	0	

Table G10: Rel. abundance (%) of adult and juvenile (i.e. saplings) tree species in *Dan Teso* transect.
Note: The purple names stand for endemic species, blue for indigenous species, black for exotic species.

Species of Dan Teso transect	Rel. abundance adults	Rel. abundance saplings	Other species in the area
Adenanthera p.	4	1	*Flacourtia c.*
Chrysobalanus i.	3	13	*Curculigo r.*
Cinnamomum v.	28	8	*Vanilla p.*
Deckenia n.	4	4	*Pyrostria b.*
Diospyros b.	13	7	*Anacardium o.*
Dracaena r.	0	1	
Memecylon e.	5	21	
Ochna k.	2	9	
Paragenipa l.	3	3	
Phoenicophorium b.	13	26	
Roscheria m.	0	1	
Tabebuia p.	25	1	

Table G11: Rel. abundance (%) of adult and juvenile (i.e. saplings) tree species in *Dan Marizan north* transect.
Note: The purple names stand for endemic species, blue for indigenous species, black for exotic species.

Species of Dan Marizan north transect	Rel. abundance adults	Rel. abundance saplings	Other species in the area
Adenanthera p.	0	1	*Curculigo r.*
Calophyllum i.	1	0	*Ludia m.*
Chrysobalanus i.	18	23	*Ananas c.*
Cinnamomum v.	26	2	*Aphloia t.*
Cocos n.	0	1	*Arthocarpus h.*
Dracaena r.	1	1	*Diospyros b.*
Mangifera i.	1	0	*Deckenia n.*
Memecylon e.	4	11	*Roscheria m.*
Nephrosperma v.	7	17	*Ficus l.*
Ochna k.	2	2	*Ochrosia o.*
Paragenipa l.	1	0	*Colea s.*
Phoenicophorium b.	9	42	*Psychotria p.*
Pyrostria b.	1	0	*Erythroxylum s.*
Sandoricum k.	1	0	*Pimenta d.*
Tabebuia p.	26	0	*Peponidium c.*
Terminalia c.	1	0	*Diospyros b.*
Verschaffeltia s.	1	0	*Dodonea v.*

Table G12: Rel. abundance (%) of adult and juvenile (i.e. saplings) tree species in *Dan Marizan south* transect.
Note: The purple names stand for endemic species, blue for indigenous species, black for exotic species.

Species of Dan Marizan south transect	Rel. abundance adults	Rel. abundance saplings	Other species in the area
Adenanthera p.	1	8	*Casuarina e.*
Alstonia m.	2	0	*Curculigo r.*
Barringtonia r.	0	1	*Pyrostria b.*
Calopohyllum i.	0	1	*Merremia p.*
Cananga o.	1	0	*Theobroma c.*
Chrysobalanus i.	8	12	*Arthocarpus h.*
Cinnamomum v.	19	9	*Aphloia t.*
Diospyros b.	4	0	*Arthocarpus a.*
Dracaena r.	4	5	*Memecylon c*
Falcataria m.	6	0	*Morinda c.*
Ficus l.	1	0	*Psychotria p.*
Memecylon e.	0	1	*Psidium c.*
Nephrosperma v.	0	6	*Roscheria m.*
Ochna k.	0	1	
Paragenipa l.	2	0	
Phoenicophorium b.	5	30	
Sandoricum k.	40	26	
Tabebuia p.	7	0	

Table G13: Rel. abundance (%) of adult and juvenile (i.e. saplings) tree species in *Dan Tombalo up* transect.
Note: The purple names stand for endemic species, blue for indigenous species, black for exotic species.

Species of Dan Tombalo up transect	Rel. abundance adults	Rel. abundance saplings	Other species in the area
Adenanthera p.	2	1	*Diospyros b.*
Alstonia m.	2	0	*Memecylon e.*
Chrysobalanus i.	26	17	*Pandanus u.*
Cinnamomum v.	35	4	*Psychotria p.*
Dracaena r.	0	1	*Roscheria m.*
Falcataria m.	2	0	*Vitex c.*
Nephrosperma v.	0	5	*Pandanus b.*
Ochna k.	2	3	*Curculigo r.*
Paragenipa l.	1	1	
Phoenicophorium b.	0	57	
Pyrostria b.	0	1	
Sandoricum k.	4	9	
Tabebuia p.	23	0	
Vitex d.	3	1	

Table G14: Stakeholders that did not participate to the scenario evaluation

Stakeholders	General Focus	Aim(s)	Link to the Val d'Endor watershed
District Administration (DA)	- All administrative tasks	To serve as an interface between the community in the affairs of the district and promoting access to public services at the local level	- Allocate land - Allocate waste collection areas
Landscape and Waste Management Agency (LWMA)	- Waste management	To be responsible for landscape and beautification of the country and responsible for overall waste management in Seychelles	- Collection of solid wastes through STAR
Ministry of Fisheries and Agriculture (MFA)	- Agriculture - Fishery	To be responsible for developing and supporting resilient and sustainable fisheries as well as agricultural sector	- Re-establish agriculture sector
Ministry of Foreign Affairs and Transport (MFAT)	- Foreign affairs - Transportation - Main transport infrastructure	To be responsible for Seychelles' foreign development cooperation and trade policy and in charge of overall transportation within the country	- Planning and construction of main roads
Ministry of Health (MH)	- Health	To provide affordable, accessible and high standard of health care services	- Provide health care to residents
Property Management Corporation (PMC)	- Housing	To ensure an equitable provision of accommodation to Seychellois	- Allocate governments' land
Public Health Authority (PHA)	- Health	To be responsible for disease prevention and control	- Control water quality
Seychelles Land Transport Agency (SLTA)	- Transportation - Roads	To manage local transport infrastructure in an efficient, safe, reliable and sustainable way	- Manage transport infrastructures
Seychelles Meteorological Services (MET)	- Weather - Climate	To provide weather and climate services for the safety and welfare of the local and global community	- Guide the MEECC on climate change negotiations, environment policies, laws and international treaties - Meteorological forecast
STAR	- Waste management	To collect domestic waste; to clean urban and public areas	- Waste collection
Watershed Committee	- Environment	To preserve and protect the watershed	- Clean surrounding of rivers - Plant endemic species

Table G15: Impact matrix. 0=no or very weak direct impact, 1=weak direct impact, 2=medium direct impact, 3= strong direct impact.

Impact on	*Irrigation*	*Agricultural by-products*	*Water abstraction*	*Water storage infrastructure*	*Water consumption*	*Sanitation system*	*Waste dumping*	*Roads infrastructure*	*Housing*	*Farming area*	*Legal context*	*Law enforcement*	*Extent of forest*	*Forest structure*	*Weather*	*Topography*	**Activity**
Irrigation	0	2	3	3	0	0	0	0	0	1	1	0	0	0	0	0	10
Agricultural by-products	0	0	3	0	1	0	0	0	0	0	2	1	0	1	0	0	8
Water abstraction	3	0	0	3	3	0	0	1	2	2	0	2	0	2	0	0	18
Water storage infrastructure	3	0	3	0	3	0	0	1	2	3	1	1	0	0	0	1	18
Water consumption	2	0	3	2	0	2	0	0	1	0	1	0	0	1	0	0	12
Sanitation system	0	0	2	2	0	0	0	1	1	0	1	0	0	0	0	0	7
Waste dumping	0	0	2	0	0	0	0	0	0	0	1	2	0	1	0	0	6
Roads infrastructure	0	0	2	1	0	0	2	0	1	1	0	0	1	2	0	2	12
Housing	0	0	3	3	3	3	2	3	0	2	1	0	2	2	0	2	26
Farming area	3	3	3	2	0	0	0	1	2	0	2	0	2	2	0	2	22
Legal context	2	2	2	1	1	1	1	1	3	2	0	2	2	1	0	1	22
Law enforcement	0	3	3	2	0	1	3	0	0	0	2	0	0	0	0	1	15
Extent of forest	0	0	0	0	0	0	0	0	2	2	1	0	0	2	2	3	12
Forest structure	0	0	1	0	0	0	0	0	0	1	2	1	0	0	2	1	8
Weather	3	3	3	3	2	0	0	2	0	1	1	0	1	2	0	2	23
Topography	3	1	3	2	0	1	0	2	2	3	0	0	2	3	2	0	24
Passivity	19	14	36	24	13	8	8	12	16	18	16	9	10	19	6	15	243

Table G16: Different levels of the 11 impact variables.

Impact variables	Levels
Agricultural by-products	Reduce agricultural by-products emission
	Current state
	Increase agricultural by-products emission
Water abstraction	Decrease water abstraction
	Current state
	Increase water abstraction
Water storage infrastructure	Decrease water storage infrastructures
	Current state
	Increase water storage infrastructures
Sanitation system	Current state
	Improved sanitation system
Housing	Lower number of houses
	Current state
	High density residential area
Farming area	Decrease farming area
	Current state
	Increase farming area
Legal context	Current state
	Increase legal context
Law enforcement	Current state
	Increase law enforcement
Extent of forest	Decrease extent of forest
	Current state
	Increase extent of forest
Weather	Current state
	Shift due to climate change
	Decrease artificial or natural drainage
Drainage	Current state
	Increase artificial or natural drainage

Table G17: Consistency matrix of the 11 impact variables. -1=inconsistent, 0=possibility, 1=supporting, 2=inducing.

Impact variables		Agricultural by-products			Water abstraction			Water storage infrastructure		Sanitation system			Housing			Farming area		Legal context		Law enforcement			Extent of forest		Weather		
	Levels	1	2	3	1	2	3	1	2	1	2	3	1	2	3	1	2	1	2	1	2	3	1	2	1	2	3
Water abstraction	1.decrease	0	0	0																							
	2.current state	1	0	0																							
	3.increase	1	0	1																							
Water storage infrastructure	1.decrease	0	0	0	2	-1	-1																				
	2.current state	1	0	0	1	2	1																				
	3.increase	1	0	1	-1	1	2																				
Sanitation system	1.current state	1	0	1	0	1	1	0	1	1																	
	2.increase	1	0	1	0	0	1	0	0	1																	
Housing	1.decrease	0	0	0	2	2	-1	2	-1	-1	-1	-1															
	2.current state	1	0	1	1	2	1	-1	2	1	2	1															
	3.increase	1	0	1	-1	-1	2	-1	-1	2	1	2															
Farming area	1.decrease	2	0	-1	2	0	1	0	-1	1	0	1	0	0	2												
	2.current state	1	2	0	0	2	0	-1	2	0	2	1	-1	2	1												
	3.increase	0	0	2	-1	-1	2	-1	-1	2	1	1	-1	1	2												
Legal context	1.current state	1	2	1	-1	2	1	-1	0	1	1	1	-1	1	1	1	1	1									
	2.increase	2	1	1	1	1	1	0	1	1	1	1	-1	1	1	0	1	1									
Law enforcement	1.current state	1	1	1	0	0	1	0	1	1	1	1	0	1	1	1	1	1	1	0							
	2.increase	1	1	1	0	1	1	0	1	1	1	1	0	1	1	0	1	1	1	1							
Extent of forest	1.decrease	1	0	1	0	0	1	0	0	1	1	1	0	1	2	1	0	1	1	1	1	1					
	2.current state	1	1	0	0	1	0	0	1	0	1	0	0	2	1	0	1	-1	1	1	1	1					
	3.increase	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1	0	-1	0	0	0	0					
Weather	1.current state	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2.shift	1	0	1	0	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0		
Drainage	1.decrease	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0
	2.current state	1	0	1	0	0	1	0	0	1	1	1	0	1	1	1	1	1	1	0	1	0	1	0	0	0	1
	3.increase	1	0	0	0	1	1	0	1	1	1	1	0	1	1	1	0	1	0	1	0	1	0	1	1	0	1

Table G18: Multiplicative and additive consistency values.

Scenarios	Multiplicative consistency values	Additive consistency values	Inconsistencies
Scenario 1	128	62	0
Scenario 2	32	60	0
Scenario 3	512	64	0
Scenario 4	128	62	0

Table G19: Tukey's multiple comparisons test of the one-way ANOVA comparing the scenarios' desirability (all stakeholders confounded).
Note: It compares the desirability of each scenario by pairs. Significant results are highlighted in orange. The abbreviation D1 to D4 stand for desirability of scenario 1 to desirability of scenario 4.

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
D1 vs. D2	-1.43	-2.78 to -.06	Yes	*	.04
D1 vs. D3	-2.57	-3.92 to -1.21	Yes	****	< .001
D1 vs. D4	-2.93	-4.29 to -1.57	Yes	****	< .001
D2 vs. D3	-1.14	-2.47 to .19	No	ns	.12
D2 vs. D4	-1.51	-2.84 to -.17	Yes	*	.02
D3 vs. D4	-.37	-1.70 to .96	No	ns	.89

Table G20: Tukey's multiple comparisons test of the one-way ANOVA comparing the desirability of scenario 1 (*Intensive housing)* among stakeholders.
Note: It compares the desirability of scenario 1 by pairs. Significant results are highlighted in orange. The abbreviations are: ED1 (desirability of scenario 1 for the environmental group), RD1 (desirability of scenario 1 for the residents group), FD1 (desirability of scenario 1 for the farmers group), PD1 (desirability of scenario 1 for the PUC group), SD1 (desirability of scenario 1 for the SAA group), UD1 (desirability of scenario 1 for the UniSey group), and MD1 (desirability of scenario 1 for the MLUH group).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
ED1 vs. PD1	-1.56	-4.62 to 1.49	No	ns	.70
ED1 vs. SD1	-1.07	-3.91 to 1.77	No	ns	.91
ED1 vs. UD1	-1.42	-4.72 to 1.89	No	ns	.84
ED1 vs. RD1	-5.75	-8.81 to -2.68	Yes	****	< .001
ED1 vs. MD1	.55	-2.94 to 4.04	No	ns	1.00
ED1 vs. FD1	-4.00	-7.06 to -0.93	Yes	**	< .001
PD1 vs. SD1	.49	-2.35 to 3.33	No	ns	1.00
PD1 vs. UD1	.15	-3.16 to 3.45	No	ns	> .99
PD1 vs. RD1	-4.19	-7.24 to -1.12	Yes	**	< .001
PD1 vs. MD1	2.11	-1.37 to 5.60	No	ns	.51
PD1 vs. FD1	-2.44	-5.49 to .62	No	ns	.20
SD1 vs. UD1	-.35	-3.45 to 2.75	No	ns	1.00
SD1 vs. RD1	-4.68	-7.52 to -1.83	Yes	***	< .001
SD1 vs. MD1	1.62	-1.68 to 4.92	No	ns	.74
SD1 vs. FD1	-2.93	-5.77 to -.08	Yes	*	.04
UD1 vs. RD1	-4.33	-7.64 to -1.02	Yes	**	<.001
UD1 vs. MD1	1.97	-1.74 to 5.67	No	ns	.66
UD1 vs. FD1	-2.58	-5.89 to .72	No	ns	.22
RD1 vs. MD1	6.30	2.81 to 9.79	Yes	****	< .001
RD1 vs. FD1	1.75	-1.31 to 4.81	No	ns	.58
MD1 vs. FD1	-4.55	-8.04 to -1.06	Yes	**	< .001

Table G21: Tukey's multiple comparisons test of the one-way ANOVA comparing the desirability of scenario 2 (*Increased farming)* among stakeholders.
Note: It compares the desirability of scenario 2 by pairs. Significant results are highlighted in orange. The abbreviations are: ED2 (desirability of scenario 2 for the environmental group), RD2 (desirability of scenario 2 for the residents group), FD2 (desirability of scenario 2 for the farmers group), PD2 (desirability of scenario 2 for the PUC group), SD2 (desirability of scenario 2 for the SAA group), UD2 (desirability of scenario 2 for the UniSey group), and MD2 (desirability of scenario 2 for the MLUH group).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
ED2 vs. PD2	-.62	-4.73 to 3.48	No	ns	1.00
ED2 vs. SD2	-3.90	-7.72 to -.07	Yes	*	.04
ED2 vs. UD2	.54	-3.90 to 4.98	No	ns	1.00
ED2 vs. RD2	-2.29	-6.28 to 1.70	No	ns	.58
ED2 vs. MD2	-.43	-5.11 to 4.26	No	ns	> .99
ED2 vs. FD2	-3.53	-7.42 to .37	No	ns	.10
PD2 vs. SD2	-3.27	-7.09 to .54	No	ns	.14
PD2 vs. UD2	1.17	-3.27 to 5.60	No	ns	.98
PD2 vs. RD2	-1.67	-5.66 to 2.33	No	ns	.86
PD2 vs. MD2	.20	-4.48 to 4.88	No	ns	> .99
PD2 vs. FD2	-2.90	-6.80 to 1.00	No	ns	.27
SD2 vs. UD2	4.44	.26 to 8.61	Yes	*	.03
SD2 vs. RD2	1.61	-2.09 to 5.30	No	ns	.83
SD2 vs. MD2	3.47	-.96 to 7.90	No	ns	.22
SD2 vs. FD2	.37	-3.22 to 3.96	No	ns	> .99
UD2 vs. RD2	-2.83	-7.16 to 1.50	No	ns	.42
UD2 vs. MD2	-.97	-5.94 to 4.01	No	ns	1.00
UD2 vs. FD2	-4.07	-8.31 to .18	No	ns	.07
RD2 vs. MD2	1.87	-2.72 to 6.45	No	ns	.87
RD2 vs. FD2	-1.23	-5.01 to 2.54	No	ns	.95
MD2 vs. FD2	-3.10	-7.60 to 1.40	No	ns	.36

Table G22: Mean (*M*) and Standard Deviation (*SD*) values for the desirability of the scenario 3 (*Better managed water catchment*).
Note: The abbreviations are: ED3 (desirability of scenario 3 for the environmental group), RD3 (desirability of scenario 3 for the residents group), FD3 (desirability of scenario 3 for the farmers group), PD3 (desirability of scenario 3 for the PUC group), SD3 (desirability of scenario 3 for the SAA group), UD3 (desirability of scenario 3 for the UniSey group), and MD3 (desirability of scenario 3 for the MLUH group). n stands for the number of participants per stakeholder group.

	ED3	PD3	SD3	UD3	RD3	MD3	FD3
n	8.00	8.00	11.00	6.00	9.00	5.00	10.00
M	7.19	7.06	5.55	7.67	6.11	6.80	5.00
SD	2.99	2.68	2.62	3.09	2.62	2.39	2.00

Table G23: Mean (*M*) and Standard Deviation (*SD*) values for the desirability of the scenario 4 (*Better regulated intensification of housing and farming*).
Note: The abbreviations are: ED4 (desirability of scenario 4 for the environmental group), RD4 (desirability of scenario 4 for the residents group), FD4 (desirability of scenario 4 for the farmers group), PD4 (desirability of scenario 4 for the PUC group), SD4 (desirability of scenario 4 for the SAA group), UD4 (desirability of scenario 4 for the UniSey group), and MD4 (desirability of scenario 4 for the MLUH group). n stands for the number of participants per stakeholder group.

	ED4	PD4	SD4	UD4	RD4	MD4	FD4
n	8.00	8.00	11.00	6.00	9.00	5.00	10.00
M	8.13	7.19	6.73	7.75	5.00	8.00	5.30
SD	1.79	2.10	2.49	2.19	3.74	2.12	1.34

Table G24: Tukey's multiple comparisons test of the one-way ANOVA comparing the desirability of scenario 4 (*Better regulated intensification of housing and farming)* among stakeholders.
Note: It compares the desirability of scenario 4 by pairs. The abbreviations are: ED4 (desirability of scenario 4 for the environmental group), RD4 (desirability of scenario 4 for the residents group), FD4 (desirability of scenario 4 for the farmers group), PD4 (desirability of scenario 4 for the PUC group), SD4 (desirability of scenario 4 for the SAA group), UD4 (desirability of scenario 4 for the UniSey group), and MD4 (desirability of scenario 4 for the MLUH group).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
ED4 vs. PD4	.94	-2.73 to 4.60	No	ns	.99
ED4 vs. SD4	1.40	-2.01 to 4.80	No	ns	.87
ED4 vs. UD4	.38	-3.58 to 4.33	No	ns	> .99
ED4 vs. RD4	3.13	-.44 to 6.69	No	ns	.12
ED4 vs. MD4	.13	-4.05 to 4.30	No	ns	> .99
ED4 vs. FD4	2.83	-.65 to 6.30	No	ns	.18
PD4 vs. SD4	.46	-2.95 to 3.87	No	ns	1.00
PD4 vs. UD4	-.56	-4.52 to 3.40	No	ns	1.00
PD4 vs. RD4	2.19	-1.37 to 5.75	No	ns	.50
PD4 vs. MD4	-.81	-4.99 to 3.37	No	ns	1.00
PD4 vs. FD4	1.89	-1.59 to 5.36	No	ns	.64
SD4 vs. UD4	-1.02	-4.74 to 2.70	No	ns	.98
SD4 vs. RD4	1.73	-1.57 to 5.02	No	ns	.68
SD4 vs. MD4	-1.27	-5.23 to 2.68	No	ns	.95
SD4 vs. FD4	1.43	-1.78 to 4.63	No	ns	.82
UD4 vs. RD4	2.75	-1.11 to 6.61	No	ns	.32
UD4 vs. MD4	-.25	-4.69 to 4.19	No	ns	> .99
UD4 vs. FD4	2.45	-1.34 to 6.24	No	ns	.44
RD4 vs. MD4	-3.00	-7.09 to 1.09	No	ns	.29
RD4 vs. FD4	-.30	-3.67 to 3.07	No	ns	> .99
MD4 vs. FD4	2.70	-1.32 to 6.72	No	ns	.39

Table G25: Tukey's multiple comparisons test of the one-way ANOVA comparing the probability of scenario 2 (*Increased farming)* among stakeholders.
Note: It compares the probability of scenario 2 by pairs. Significant results are highlighted in orange. The abbreviations are: EP2 (desirability of scenario 2 for the environmental group), RP2 (desirability of scenario 2 for the residents group), FP2 (desirability of scenario 2 for the farmers group), PP2 (desirability of scenario 2 for the PUC group), SP2 (desirability of scenario 2 for the SAA group), UP2 (desirability of scenario 2 for the UniSey group), and MP2 (desirability of scenario 2 for the MLUH group).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
EP2 vs. PP2	-1.56	-4.64 to 1.51	No	ns	.71
EP2 vs. SP2	-2.80	-5.66 to .05	No	ns	.06
EP2 vs. UP2	-3.60	-6.92 to -.28	Yes	*	.03
EP2 vs. RP2	-2.94	-5.92 to .05	No	ns	.06
EP2 vs. MP2	-3.04	-6.54 to .47	No	ns	.13
EP2 vs. FP2	-2.74	-5.65 to .18	No	ns	.08
PP2 vs. SP2	-1.24	-4.09 to 1.62	No	ns	.83
PP2 vs. UP2	-2.04	-5.36 to 1.28	No	ns	.50
PP2 vs. RP2	-1.38	-4.36 to 1.61	No	ns	.79
PP2 vs. MP2	-1.48	-4.98 to 2.03	No	ns	.85
PP2 vs. FP2	-1.18	-4.09 to 1.74	No	ns	.88
SP2 vs. UP2	-.80	-3.92 to 2.32	No	ns	.99
SP2 vs. RP2	-.14	-2.90 to 2.63	No	ns	> .99
SP2 vs. MP2	-.24	-3.55 to 3.083	No	ns	> .99
SP2 vs. FP2	.06	-2.62 to 2.75	No	ns	> .99
UP2 vs. RP2	.67	-2.57 to 3.91	No	ns	1.00
UP2 vs. MP2	.57	-3.1 to 4.29	No	ns	1.00
UP2 vs. FP2	.87	-2.31 to 4.05	No	ns	.98
RP2 vs. MP2	-.10	-3.53 to 3.33	No	ns	> .99
RP2 vs. FP2	.20	-2.62 to 3.02	No	ns	> .99
MP2 vs. FP2	.30	-3.07 to 3.67	No	ns	> .99

Table G26: Tukey's multiple comparisons test of the one-way ANOVA comparing the scenarios' desirability for the environmental group.
Note: It compares the desirability of each scenario by pairs. The abbreviation ED1 to ED4 stand for Desirability of scenario 1 to Desirability of scenario 4. Significant results are highlighted in orange.

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
ED1 vs. ED2	-1.63	-5.03 to 1.78	No	ns	.57
ED1 vs. ED3	-5.44	-8.84 to -2.02	Yes	***	< .001
ED1 vs. ED4	-6.38	-9.78 to -2.96	Yes	***	< .001
ED2 vs. ED3	-3.81	-7.22 to -0.40	Yes	*	.02
ED2 vs. ED4	-4.75	-8.16 to -1.34	Yes	**	< .001
ED3 vs. ED4	-.94	-4.34 to 2.47	No	ns	.88

Table G27: Tukey's multiple comparisons test of the one-way ANOVA comparing the scenarios' desirability for the stakeholder group PUC.
Note: It compares the desirability of each scenario by pairs. Significant results are highlighted in orange. The abbreviation PD1 to PD4 stand for Desirability for PUC stakeholders of scenario 1 to Desirability of scenario 4 for PUC stakeholders.

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
PD1 vs. PD2	-.69	-3.92 to 2.55	No	ns	.94
PD1 vs. PD3	-3.75	-6.98 to -.51	Yes	*	.02
PD1 vs. PD4	-3.88	-7.11 to -.63	Yes	*	.01
PD2 vs. PD3	-3.06	-6.30 to .17	No	ns	.07
PD2 vs. PD4	-3.19	-6.42 to .05	No	ns	.06
PD3 vs. PD4	-.13	-3.36 to 3.11	No	ns	1.00

Table G28: Tukey's multiple comparisons test of the one-way ANOVA comparing the scenarios' desirability for the stakeholder group SAA.
Note: It compares the desirability of each scenario by pairs. Significant results are highlighted in orange. The abbreviation SD1 to SD4 stand for Desirability for SAA stakeholders of scenario 1 to Desirability of scenario 4 for SAA stakeholders.

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
SD1 vs. SD2	-4.46	-6.93 to -1.97	Yes	***	<.001
SD1 vs. SD3	-2.73	-5.21 to -0.24	Yes	*	.03
SD1 vs. SD4	-3.91	-6.39 to -1.42	Yes	***	<.001
SD2 vs. SD3	1.73	-0.75 to 4.21	No	ns	.26
SD2 vs. SD4	.55	-1.93 to 3.02	No	ns	.93
SD3 vs. SD4	-1.18	-3.66 to 1.30	No	ns	.58

Table G29: Tukey's multiple comparisons test of the one-way ANOVA comparing the scenarios' desirability for the stakeholder group UniSey.
Note: It compares the desirability of each scenario by pairs. Significant results are highlighted in orange. The abbreviation UD1 to UD4 stand for Desirability for UniSey stakeholders of scenario 1 to Desirability of scenario 4 for UniSey stakeholders.

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
UD1 vs. UD2	.33	-3.69 to 4.36	No	ns	1.00
UD1 vs. UD3	-4.50	-8.53 to -0.47	Yes	*	.03
UD1 vs. UD4	-4.58	-8.61 to -0.55	Yes	*	.02
UD2 vs. UD3	-4.83	-8.86 to -0.80	Yes	*	.02
UD2 vs. UD4	-4.92	-8.94 to -0.88	Yes	*	.01
UD3 vs. UD4	-.08	-4.11 to 3.94	No	ns	> .99

Table G30: Tukey's multiple comparisons test of the one-way ANOVA comparing the scenarios' desirability for the stakeholder group MLUH (Ministry of Land Use and Housing).
Note: It compares the desirability of each scenario by pairs. Significant results are highlighted in orange. The abbreviation MD1 to MD4 stand for Desirability for MLUH stakeholders of scenario 1 to Desirability of scenario 4 for MLUH stakeholders.

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
MD1 vs. MD2	-2.60	-7.60 to 2.40	No	ns	.47
MD1 vs. MD3	-5.60	-10.60 to -.59	Yes	*	.03
MD1 vs. MD4	-6.80	-11.80 to -1.79	Yes	**	.01
MD2 vs. MD3	-3.00	-8.00 to 2.00	No	ns	.35
MD2 vs. MD4	-4.20	-9.20 to .80	No	ns	.12
MD3 vs. MD4	-1.20	-6.20 to 3.80	No	ns	.90

Table G31: Mean and Standard Deviation of the five criteria in the current state situation of all participants confounded. NOTE: n stands for the sample size.

	Water supply	*Housing and infrastructure*	*Farming development*	*Environmental protection*	*Retention capacity and flood protection*
n	57.00	57.00	57.00	57.00	57.00
Mean	4.50	4.45	5.21	3.77	3.57
SD	1.37	1.37	1.27	1.51	1.64

Table G32: Tukey's multiple comparisons test of the one-way ANOVA comparing the criterion *Water supply* in the four different scenarios.
Note: It compares *Water supply* in the different scenarios by pairs. Significant results are highlighted in orange. The abbreviations are: WS1 (*Water supply* in scenario 1), WS2 (*Water supply* in scenario 2), WS4 (*Water supply* in scenario 4).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
WS1 vs. WS2	-0.44	-1.25 to .37	No	ns	.50
WS1 vs. WS3	-1.14	-1.96 to -.32	Yes	**	< .001
WS1 vs. WS4	-1.87	-2.68 to -1.05	Yes	****	< .001
WS2 vs. WS3	-.70	-1.50 to .10	No	ns	.11
WS2 vs. WS4	-1.42	-2.22 to -.62	Yes	****	< .001
WS3 vs. WS4	-.72	-1.52 to .08	No	ns	.10

Table G33: Tukey's multiple comparisons test of the one-way ANOVA comparing the criterion *Housing and infrastructure* in the four different scenarios.
Note: It compares *Housing and infrastructure* in the different scenarios by pairs. Significant results are highlighted in orange. The abbreviations are: HI1 (*Housing and infrastructure* in scenario 1), HI2 (*Housing and infrastructure* in scenario 2), WS3 (*Housing and infrastructure* in scenario 3), and HI4 (*Housing and infrastructure* in scenario 4).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
HI1 vs. HI2	-.67	-1.44 to .10	No	ns	.11
HI1 vs. HI3	-1.14	-1.91 to -.35	Yes	**	< .001
HI1 vs. HI4	-1.57	-2.34 to -.79	Yes	****	< .001
HI2 vs. HI3	-.46	-1.23 to .30	No	ns	.41
HI2 vs. HI4	-.89	-1.66 to -.12	Yes	*	.02
HI3 vs. HI4	-.43	-1.20 to .34	No	ns	.47

Table G34: Tukey's multiple comparisons test of the one-way ANOVA comparing the criterion *Farming development* in the four different scenarios.
Note: It compares *Farming development* in the different scenarios by pairs. Significant results are highlighted in orange. The abbreviations are: FD1 (*Farming development* in scenario 1), FD2 (*Farming development* in scenario 2), FD3 (*Farming development* in scenario 3), and FD4 (*Farming development* in scenario 4).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
FD1 vs. FD2	-1.38	-2.23 to -0.52	Yes	***	< .001
FD1 vs. FD3	-1.54	-2.39 to -.68	Yes	****	< .001
FD1 vs. FD4	-2.23	-3.08 to -1.36	Yes	****	< .001
FD2 vs. FD3	-.16	-1.01 to .68	No	ns	.96
FD2 vs. FD4	-.85	-1.70 to .001	No	ns	.05
FD3 vs. FD4	-.69	-1.54 to .15	No	ns	.16

Table G35: Tukey's multiple comparisons test of the one-way ANOVA comparing criterion *Environmental protection* in the four different scenarios.
Note: It compares the *Environmental protection* in the different scenarios by pairs. Significant results are highlighted in orange. The abbreviations are: EP1 (*Environmental protection* in scenario 1), EP2 (*Environmental protection* in scenario 2), EP3 (*Environmental protection* in scenario 3), and EP4 (*Environmental protection* in scenario 4).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
EP1 vs. EP2	-.52	-1.37 to .33	No	ns	.40
EP1 vs. EP3	-2.19	-3.05 to -1.33	Yes	****	< .001
EP1 vs. FD4	-2.32	-3.18 to -1.45	Yes	****	< .001
EP2 vs. EP3	-1.67	-2.52 to -.82	Yes	****	< .001
EP2 vs. FD4	-1.80	-2.64 to -.94	Yes	****	< .001
EP3 vs. FD4	-.13	-.97 to .72	No	ns	.98

Table G36: Tukey's multiple comparisons test of the one-way ANOVA comparing the *criterion Retention capacity and flood protection* in the four different scenarios.
Note: It compares the *Retention capacity and flood protection* in the different scenarios by pairs. Significant results are highlighted in orange. The abbreviations are: RCFP1 (*Retention capacity and flood protection* in scenario 1), RCFP2 (*Retention capacity and flood protection* in scenario 2), RCFP3 (*Retention capacity and flood protection* in scenario 3), and RCFP4 (*Retention capacity and flood protection* in scenario 4).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
RCFP1 vs. RCFP2	-.81	-1.61 to -.01	Yes	*	.04
RCFP1 vs. RCFP3	-1.69	-2.48 to -.89	Yes	****	< .001
RCFP1 vs. RCFP4	-2.17	-2.96 to -1.37	Yes	****	< .001
RCFP2 vs. RCFP3	-.88	-1.66 to -.09	Yes	*	.02
RCFP2 vs. RCFP4	-1.35	-2.13 to -.56	Yes	****	< .001
RCFP3 vs. RCFP4	-.47	-1.25 to .31	No	ns	.40

Table G37: Mean (M) and Standard Deviation (SD) of the five criteria in the four scenarios of all participants confounded.
Note: n stands for the sample size.

		Scenarios			
		1	2	3	4
Water supply	*n*	53.00	57.00	56.00	57.00
	M	-0.32	0.12	0.82	1.54
	SD	1.86	1.79	1.64	1.26
Housing and infrastructure	*n*	55.00	57.00	56.00	57.00
	M	-0.69	-0.02	0.45	0.88
	SD	1.65	1.60	1.46	1.62
Farming development	*n*	55.00	57.00	57.00	56.00
	M	-0.80	0.58	0.74	1.43
	SD	1.81	1.82	1.81	1.54
Environmental protection	*n*	54.00	57.00	56.00	57.00
	M	-0.89	-0.37	1.30	1.40
	SD	1.89	1.83	1.72	1.47
Retention capacity and flood protection	*n*	54.00	57.00	57.00	57.00
	M	-0.81	0.00	0.88	1.35
	SD	1.65	1.73	1.65	1.43

Table G38: Tukey's multiple comparisons test of the one-way ANOVA comparing the satisfaction of the different stakeholder groups about *Water supply* criterion in *Intensive Housing* (scenario 1).
Note: Significant results are highlighted in orange. The abbreviations are EWS1 (*Water supply* in scenario 1 according to the environmental group), PWS1 (*Water supply* in scenario 1 according to PUC), SWS1 (*Water supply* in scenario 1 according to SAA), UWS1 (*Water supply* in scenario 1 according to UniSey group), RWS1 (*Water supply* in scenario 1 according to residents), MWS1 (*Water supply* in scenario 1 according to MLUH), FWS1 (*Water supply* in scenario 1 according to farmers).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
EWS1 vs. PWS1	-1.50	-4.19 to 1.19	No	ns	.61
EWS1 vs. SWS1	-.59	-3.00 to 1.82	No	ns	.99
EWS1 vs. UWS1	-1.07	-3.76 to 1.62	No	ns	.88
EWS1 vs. RWS1	-1.75	-4.35 to .84	No	ns	.39
EWS1 vs. MWS1	-.50	-3.46 to 2.46	No	ns	1.00
EWS1 vs. FWS1	-3.13	-5.72 to -.52	Yes	**	.01
PWS1 vs. SWS1	.91	-1.60 to 3.42	No	ns	.92
PWS1 vs. UWS1	.43	-2.35 to 3.20	No	ns	1.00
PWS1 vs. RWS1	-.25	-2.94 to 2.44	No	ns	> .99
PWS1 vs. MWS1	1.00	-2.04 to 4.04	No	ns	.95
PWS1 vs. FWS1	-1.63	-4.31 to 1.06	No	ns	.52
SWS1 vs. UWS1	-.48	-2.99 to 2.03	No	ns	1.00
SWS1 vs. RWS1	-1.16	-3.57 to 1.25	No	ns	.76
SWS1 vs. MWS1	.09	-2.71 to 2.89	No	ns	> .99
SWS1 vs. FWS1	-2.53	-4.95 to -.11	Yes	*	.03
UWS1 vs. RWS1	-.68	-3.37 to 2.01	No	ns	.99
UWS1 vs. MWS1	.57	-2.47 to 3.61	No	ns	1.00
UWS1 vs. FWS1	-2.05	-4.74 to .63	No	ns	.24
RWS1 vs. MWS1	1.25	-1.71 to 4.21	No	ns	.85
RWS1 vs. FWS1	-1.38	-3.97 to 1.22	No	ns	.67
MWS1 vs. FWS1	-2.63	-5.58 to .33	No	ns	.11

Table G39: Tukey's multiple comparisons test of the one-way ANOVA comparing the satisfaction of the different stakeholder groups about *Farming development* criterion in *Increased farming* (scenario 2).
Note: Significant results are highlighted in orange. The abbreviations are EFD2 (*Farming development* supply in scenario 2 according to the environmental group), PFD2 (*Farming development* in scenario 2 according to PUC), SFD2 (*Farming development* in scenario 2 according to SAA), UFD2 (*Farming development* in scenario 2 according to UniSey group), RFD2 (*Farming* development in scenario 2 according to residents), MFD2 (*Farming development* in scenario 2 according to MLUH), FFD2 (*Farming development* in scenario 2 according to farmers).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
EFD2 vs. PFD2	.13	-2.48 to 2.73	No	ns	> .99
EFD2 vs. SFD2	-1.03	-3.46 to 1.39	No	ns	.85
EFD2 vs. UFD2	.59	-2.11 to 3.29	No	ns	.99
EFD2 vs. RFD2	-1.35	-3.88 to 1.19	No	ns	.67
EFD2 vs. MFD2	-.93	-3.90 to 2.05	No	ns	.96
EFD2 vs. FFD2	-2.03	-4.50 to .45	No	ns	.18
PFD2 vs. SFD2	-1.16	-3.58 to 1.27	No	ns	.76
PFD2 vs. UFD2	.46	-2.24 to 3.17	No	ns	1.00
PFD2 vs. RFD2	-1.47	-4.01 to 1.06	No	ns	.57
PFD2 vs. MFD2	-1.05	-4.03 to 1.93	No	ns	.93
PFD2 vs. FFD2	-2.15	-4.63 to .32	No	ns	.13
SFD2 vs. UFD2	1.62	-.90 to 4.15	No	ns	.45
SFD2 vs. RFD2	-.31	-2.66 to 2.03	No	ns	1.00
SFD2 vs. MFD2	.11	-2.71 to 2.92	No	ns	> .99
SFD2 vs. FFD2	-.99	-3.27 to 1.29	No	ns	.83
UFD2 vs. RFD2	-1.94	-4.57 to .69	No	ns	.29
UFD2 vs. MFD2	-1.51	-4.57 to 1.54	No	ns	.73
UFD2 vs. FFD2	-2.61	-5.19 to -.03	Yes	*	.04
RFD2 vs. MFD2	.42	-2.49 to 3.33	No	ns	1.00
RFD2 vs. FFD2	-.68	-3.08 to 1.72	No	ns	.98
MFD2 vs. FFD2	-1.10	-3.96 to 1.76	No	ns	.90

Table G40: Tukey's multiple comparisons test of the one-way ANOVA comparing the satisfaction of the different stakeholder groups about *Farming development* criterion in *Better protected water catchment* (scenario 3).
Note: Significant results are highlighted in orange. The abbreviations are EFD3 (*Farming development* supply in scenario 3 according to the environmental group), PFD3 (*Farming development* in scenario 3 according to PUC), SFD3 (*Farming development* in scenario 3 according to SAA), UFD3 (*Farming development* in scenario 3 according to UniSey group), RFD3 (*Farming development* in scenario 3 according to residents), MFD3 (*Farming development* in scenario 3 according to MLUH), FFD3 (*Farming development* in scenario 3 according to farmers).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
EFD3 vs. PFD3	-.38	-2.96 to 2.21	No	ns	1.00
EFD3 vs. SFD3	1.11	-1.28 to 3.51	No	ns	.79
EFD3 vs. UFD3	-.11	-2.78 to 2.56	No	ns	> .99
EFD3 vs. RFD3	-.58	-3.09 to 1.92	No	ns	.99
EFD3 vs. MFD3	1.95	-.99 to 4.89	No	ns	.41
EFD3 vs. FFD3	-.95	-3.40 to 1.50	No	ns	.90
PFD3 vs. SFD3	1.49	-.91 to 3.89	No	ns	.49
PFD3 vs. UFD3	.27	-2.40 to 2.94	No	ns	> .99
PFD3 vs. RFD3	-.21	-2.72 to 2.30	No	ns	> .99
PFD3 vs. MFD3	2.33	-0.62 to 5.27	No	ns	.21
PFD3 vs. FFD3	-.58	-3.02 to 1.87	No	ns	.99
SFD3 vs. UFD3	-1.22	-3.72 to 1.27	No	ns	.74
SFD3 vs. RFD3	-1.70	-4.02 to .62	No	ns	.29
SFD3 vs. MFD3	.84	-1.95 to 3.62	No	ns	.97
SFD3 vs. FFD3	-2.06	-4.32 to .19	No	ns	.09
UFD3 vs. RFD3	-.48	-3.08 to 2.12	No	ns	1.00
UFD3 vs. MFD3	2.06	-.96 to 5.08	No	ns	.38
UFD3 vs. FFD3	-.84	-3.39 to 1.70	No	ns	.95
RFD3 vs. MFD3	2.53	-.34 to 5.41	No	ns	.12
RFD3 vs. FFD3	-.37	-2.74 to 2.01	No	ns	1.00
MFD3 vs. FFD3	-2.90	-5.73 to -.06	Yes	*	.04

Table G41: Tukey's multiple comparisons test of the one-way ANOVA comparing the satisfaction of the different stakeholder groups about *Environmental protection* criterion in *Intensive Housing* (scenario 1).
Note: Significant results are highlighted in orange. The abbreviations are EEP1 (*Environmental protection* in scenario 1 according to the environmental group), PEP1 (*Environmental protection* in scenario 1 according to PUC), SEP1 (*Environmental protection* in scenario 1 according to SAA), UEP1 (*Environmental protection* in scenario 1 according to UniSey group), REP1 (*Environmental protection* in scenario 1 according to residents), MEP1 (*Environmental protection* in scenario 1 according to MLUH), FEP1 (*Environmental protection* in scenario 1 according to farmers).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
EEP1 vs. PEP1	-2.00	-4.28 to .28	No	ns	.12
EEP1 vs. SEP1	-1.38	-3.50 to .75	No	ns	.44
EEP1 vs. UEP1	-.38	-2.74 to 1.99	No	ns	1.00
EEP1 vs. REP1	-1.75	-4.03 to .53	No	ns	.24
EEP1 vs. MEP1	-.58	-3.18 to 2.03	No	ns	.99
EEP1 vs. FEP1	-4.00	-6.28 to -1.71	Yes	****	< .001
PEP1 vs. SEP1	.63	-1.5 to 2.75	No	ns	.97
PEP1 vs. UEP1	1.63	-0.74 to 3.99	No	ns	.36
PEP1 vs. REP1	.25	-2.03 to 2.53	No	ns	1.00
PEP1 vs. MEP1	1.43	-1.18 to 4.03	No	ns	.63
PEP1 vs. FEP1	-2.00	-4.28 to .28	No	ns	.12
SEP1 vs. UEP1	1.00	-1.21 to 3.21	No	ns	.80
SEP1 vs. REP1	-.38	-2.50 to 1.75	No	ns	1.00
SEP1 vs. MEP1	.80	-1.67 to 3.27	No	ns	.95
SEP1 vs. FEP1	-2.63	-4.75 to -.49	Yes	**	.01
UEP1 vs. REP1	-1.38	-3.74 to .99	No	ns	.56
UEP1 vs. MEP1	-.20	-2.88 to 2.48	No	ns	> .99
UEP1 vs. FEP1	-3.63	-5.99 to -1.25	Yes	***	< .001
REP1 vs. MEP1	1.18	-1.43 to 3.78	No	ns	.81
REP1 vs. FEP1	-2.25	-4.53 to .03	No	ns	.06
MEP1 vs. FEP1	-3.43	-6.03 to -.81	Yes	**	< .001

Table G42: Tukey’s multiple comparisons test of the one-way ANOVA comparing the satisfaction of the different stakeholder groups about *Environmental protection* criterion in *Increased farming* (scenario 2).
Note: Significant results are highlighted in orange. The abbreviations are EEP2 (*Environmental protection* in scenario 2 according to the environmental group), PEP2 (*Environmental protection* in scenario 2 according to PUC), SEP2 (*Environmental protection* in scenario 2 according to SAA), UEP2 (*Environmental protection* in scenario 2 according to UniSey group), REP2 (*Environmental protection* in scenario 2 according to residents), MEP2 (*Environmental protection* in scenario 2 according to MLUH), FEP2 (*Environmental protection* in scenario 2 according to farmers).

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
EEP2 vs. PEP2	-.63	-2.95 to 1.70	No	ns	.98
EEP2 vs. SEP2	-2.02	-4.19 to .14	No	ns	.08
EEP2 vs. UEP2	.11	-2.30 to 2.52	No	ns	> .99
EEP2 vs. REP2	-2.53	-4.79 to -.26	Yes	*	.02
EEP2 vs. MEP2	-.75	-3.41 to 1.91	No	ns	.98
EEP2 vs. FEP2	-2.65	-4.86 to -.43	Yes	**	.01
PEP2 vs. SEP2	-1.40	-3.56 to .770	No	ns	.44
PEP2 vs. UEP2	.73	-1.68 to 3.14	No	ns	.97
PEP2 vs. REP2	-1.90	-4.17 to .36	No	ns	.16
PEP2 vs. MEP2	-.13	-2.78 to 2.53	No	ns	> .99
PEP2 vs. FEP2	-2.03	-4.23 to .18	No	ns	.09
SEP2 vs. UEP2	2.13	-.12 to 4.38	No	ns	.08
SEP2 vs. REP2	-.51	-2.60 to 1.59	No	ns	.99
SEP2 vs. MEP2	1.27	-1.24 to 3.78	No	ns	.71
SEP2 vs. FEP2	-.63	-2.66 to 1.41	No	ns	.96
UEP2 vs. REP2	-2.64	-4.98 to -.28	Yes	*	.02
UEP2 vs. MEP2	-.86	-3.58 to 1.87	No	ns	.96
UEP2 vs. FEP2	-2.76	-5.05 to -.45	Yes	**	.01
REP2 vs. MEP2	1.78	-.82 to 4.38	No	ns	.37
REP2 vs. FEP2	-.12	-2.26 to 2.02	No	ns	> .99
MEP2 vs. FEP2	-1.90	-4.45 to .65	No	ns	.27

G3 Figures

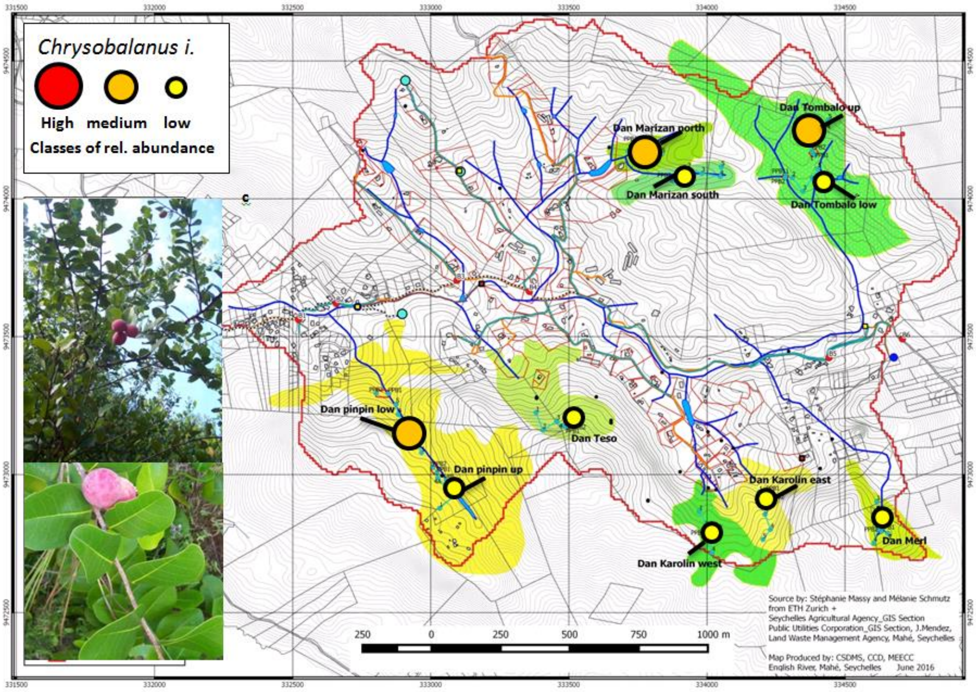


Figure G1: Distribution map of the relative abundance of *Chrysobalanus icaco.*
Note: Abundance classes: 1-10 = low invasion, 11-30 = medium invasion, >30 high invasion. Pictures source (upper and lower): Elzein, Hicham, *Chrysobalanus i.* [online image]. Retrieved September 22, 2016 from http://www.seychellesplantgallery.com/.

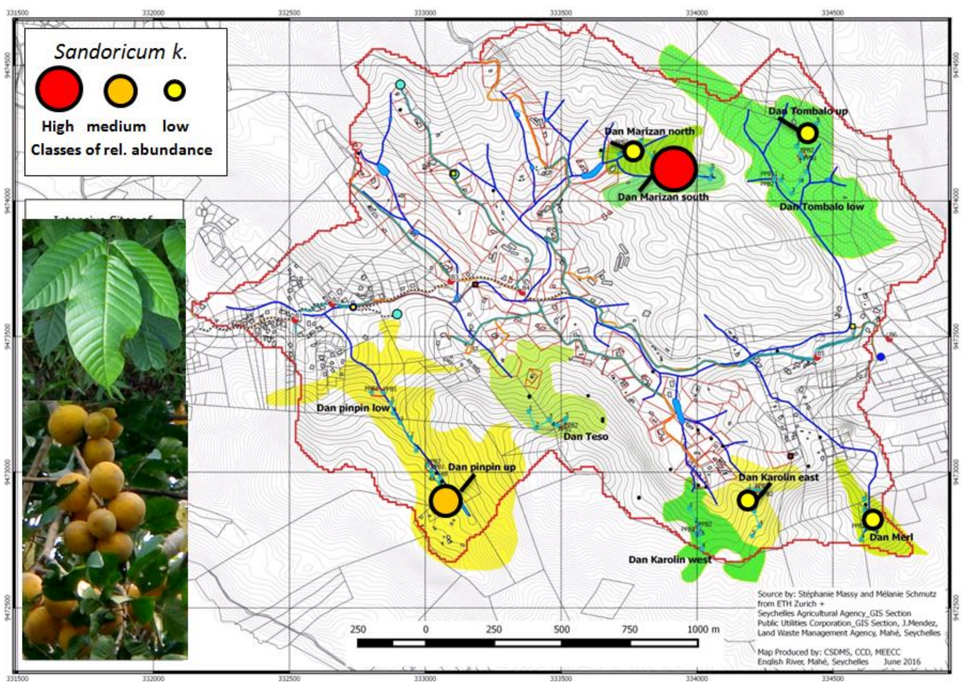


Figure G2: Distribution map of the relative abundance of *Sandoricum koetjape.*
Note: Abundance classes: 1-10 = low invasion, 11-30 = medium invasion, >30 high invasion. Pictures source: upper picture: Elzein Hicham, Sandoricum k. [online image]. Retrieved September 22, 2016 from http://www.seychellesplantgallery.com/. Lower picture: Senterre Bruno, Sandoricum k. [online image]. Retrieved September 22, 2016 from http://www.seychellesplantgallery.com/.

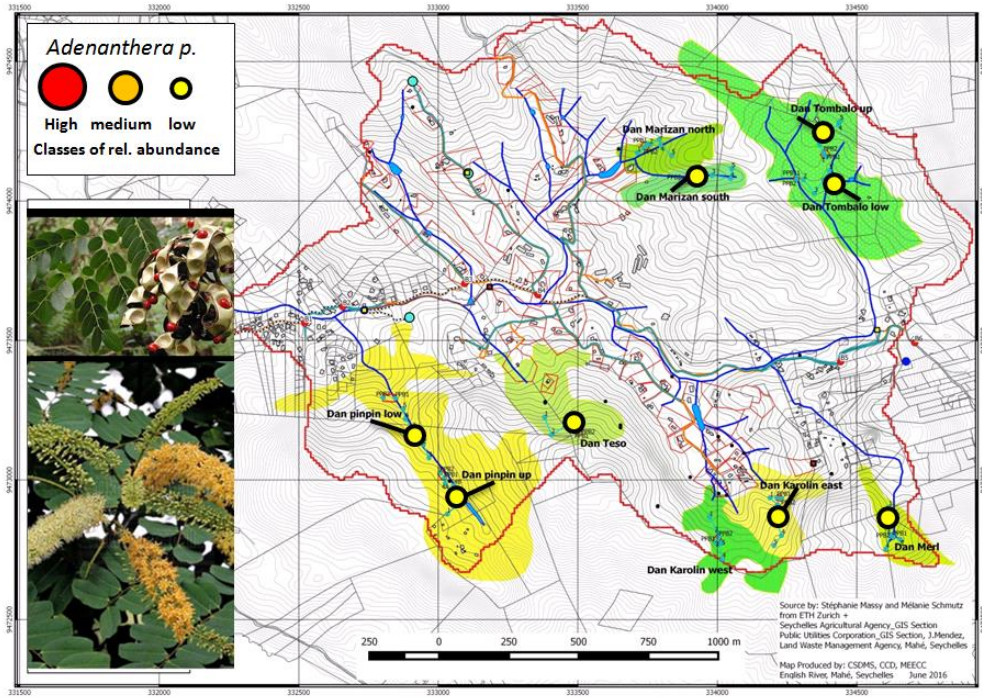


Figure G3: Distribution map of the relative abundance of *Adenanthera pavonina*.
Note: Abundance classes: 1-10 = low invasion, 11-30 = medium invasion, >30 high invasion. Pictures source: upper picture: The cook islands natural heritage trust (2007), *Adenanthera p.* [online picture]. Retrieved September 22, 2016 from http://cookislands.bishopmuseum.org/species.asp?id=5700. Lower picture: Lorenzi, H. et al. Árvores Exóticas no Brasil. Plantarum (2003). *Adenanthera p.* [online picture]. Retrieved September 22, 2016 from https://farm5.staticflickr.com/4153/5171050160_5267fc672e_o.jpg.

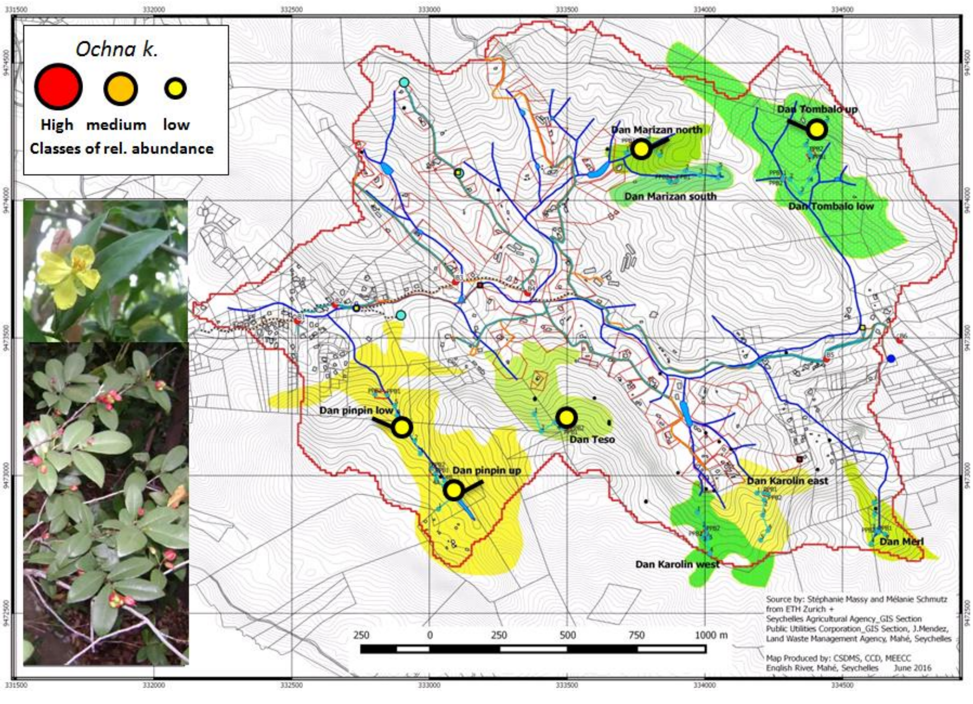


Figure G4: Distribution map of the relative abundance of *Ochna kirkii*.
Note: Abundance classes: 1-10 = low invasion, 11-30 = medium invasion, >30 high invasion. Pictures source (upper and lower): Morel Charles, Ochna k. [online picture]. Retrieved September 22, 2016 from http://www.seychellesplantgallery.com/.

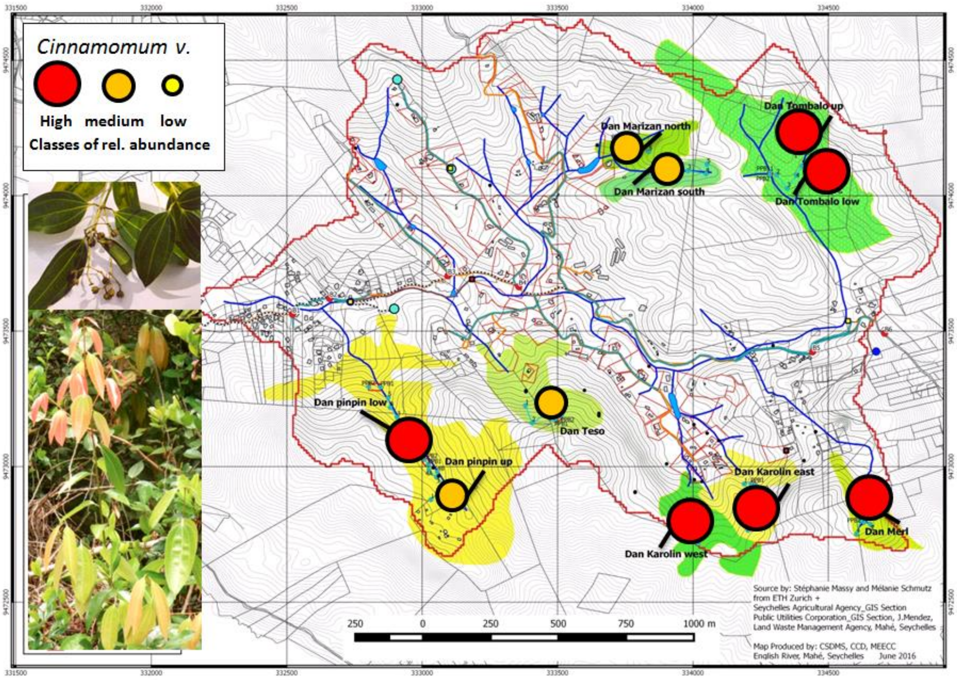


Figure G5: Distribution map of the relative abundance of *Cinnamomum verum.*
Note: Abundance classes: 1-10 = low invasion, 11-30 = medium invasion, >30 high invasion. . Pictures source: upper pictures: Unknown author, *Cinnamomum v.* [online picture]. Retrieved September 22, 2016 from https://en.wikipedia.org/wiki/File:Cinnamomum_verum1.jpg. Lower picture: Mélanie Schmutz (2016). *Cinnamomum v.* Taken on April 8, 2016.

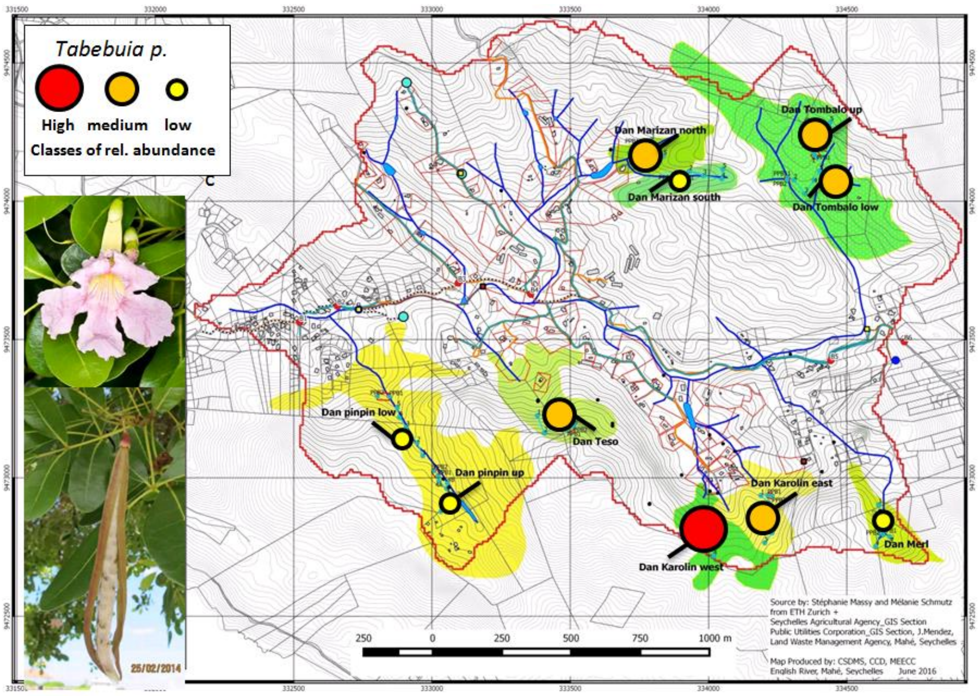


Figure G6: Distribution map of the relative abundance of *Tabebuia pallida.*
Note: Abundance classes: 1-10 = low invasion, 11-30 = medium invasion, >30 high invasion. Pictures source: upper pictures: Giuseppe Mazza, *Tabebuia p.* [online picture]. Retrieved September 22, 2016 from http://www.photomazza.com/?Tabebuia-pallida&lang=en. Lower picture: Morel Charles. *Tabebuia p.* [online picture]. Retrieved September 22, 2016 from http://www.seychellesplantgallery.com/.

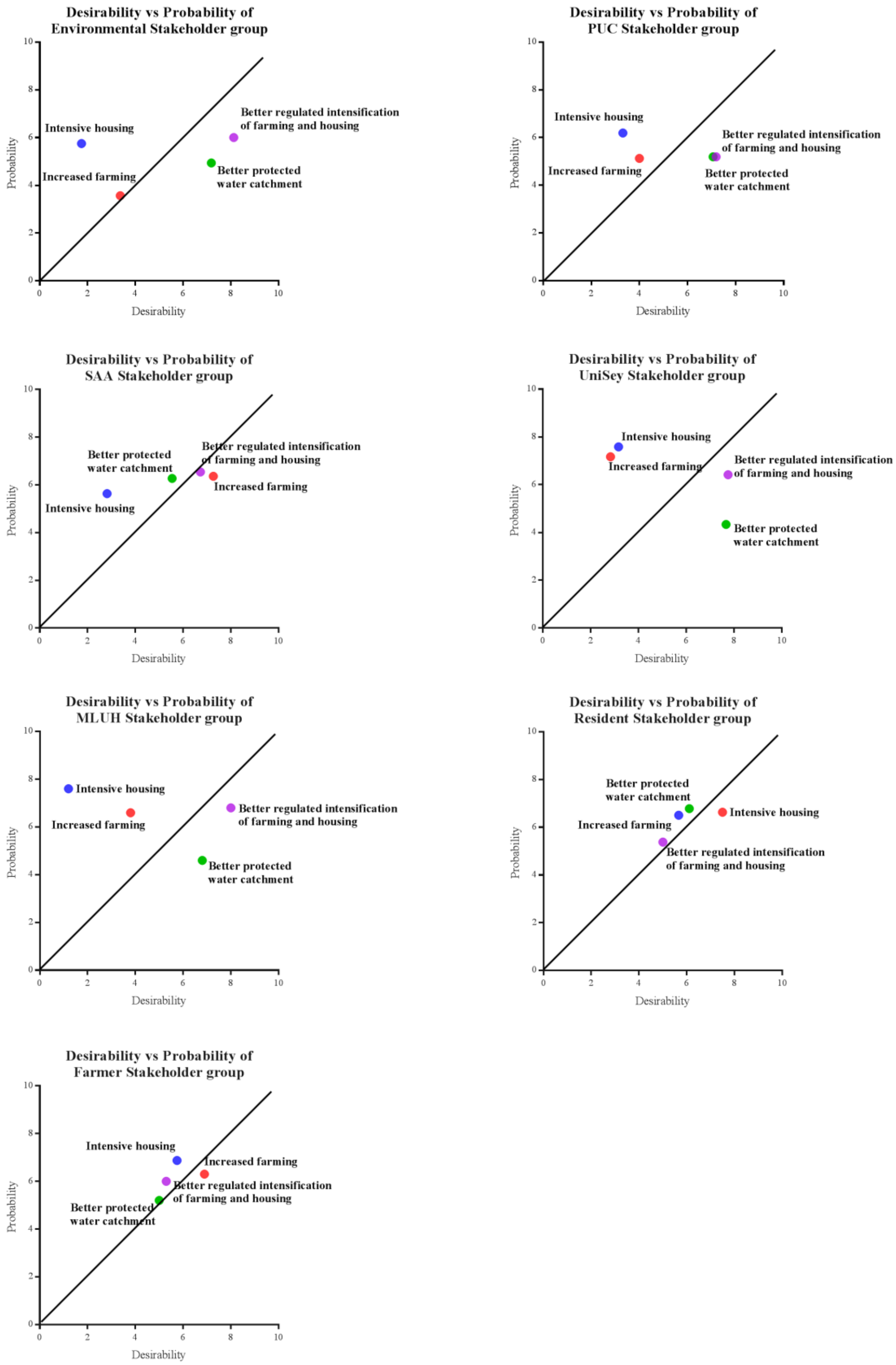


Figure G7: Desirability and Probability of each scenario for each stakeholder group.
Note: 0= not at all desirable/probable; 10= very desirable/probable.

G4 Declaration of originality

ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Declaration of originality

The signed declaration of originality is a component of every semester paper, Bachelor's thesis, Master's thesis and any other degree paper undertaken during the course of studies, including the respective electronic versions.

Lecturers may also require a declaration of originality for other written papers compiled for their courses.

I hereby confirm that I am the sole author of the written work here enclosed and that I have compiled it in my own words. Parts excepted are corrections of form and content by the supervisor.

Title of work (in block letters):

River water catchment in the Seychelles: characterization and evaluation of ecosystem services in the Val d'Endor water catchment area

Authored by (in block letters):

For papers written by groups the names of all authors are required.

Name(s):	First name(s):
Massy	Stéphanie
Schmutz	Mélanie

With my signature I confirm that

- I have committed none of the forms of plagiarism described in the 'Citation etiquette' information sheet.
- I have documented all methods, data and processes truthfully.
- I have not manipulated any data.
- I have mentioned all persons who were significant facilitators of the work.

I am aware that the work may be screened electronically for plagiarism.

Place, date

Zürich, 14/10/2016

Signature(s)

Massy

M. Schmutz

For papers written by groups the names of all authors are required. Their signatures collectively guarantee the entire content of the written paper.