

Adoption of Soil Conservation Measures in Non-agricultural Societies: The Case of a small Island



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Adoption of Soil Conservation Measures in Non-agricultural Societies: *The Case of a small Island*

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PREFACE

Before you lies the master thesis "Adoption of Soil Conservation Measures in Non-agricultural Societies: The Case of a small Island" the basis of which is a request from the Saba Conservation Foundation (SCF) and the Public Entity Saba for an erosion prevention plan for the island (see Annex 1). This erosion prevention plan can be seen as one of the products of this thesis and is the main outcome for the island itself. The thesis has been written to fulfill the graduation requirements of the master International Land and Water Management at Wageningen University, the Netherlands.

I was engaged in researching and writing this thesis from September 2017 to February 2018. Within the first week of arriving at the research location it was struck by a category 5 hurricane and a week later a second hurricane with the same force went by at close distance. I would like to thank Tim and Yvonne Muller for providing me with shelter during these insecure days and Zelda Meeuwsen for accompanying me during my stay on Saba. Furthermore I would like to thank friends and family at home that carried me through this sometimes difficult time. The devastating force of nature also marked the beginning of my research. I spend the month of September helping the islanders with cleaning up the destruction and with rebuilding the island. The resilience and endless perseverance of the islanders to rebuild their island once again is something I will never forget.

The social contacts that I made in this first month helped me to catch up with the lost research time. In consultation with my supervisors I chose to slightly deviate from the original research plan. So that when I eventually had to leave the island, I had obtained all the data that I was looking for. To my supervisors Michel Riksen and Aad Kessler: I would like to thank you for your critical feedback and helpful comments during my thesis process. Additionally, I wish to thank all Sabans and visitors of the island during the time I conducted my research, for their cooperation and for giving me an amazing time on the island.

Under dark rainy clouds and roaring wind A tiny lush green island is pinned Down in never-ending bottomless blue Giving hope to a small crew That is sailing a stranded ship Slowly losing the world's grip However they're staying strong Singing a paradise worthy song

Jesse Dirk Emmanuel Opdam

ABSTRACT

Soil erosion is affecting farmland all over the world, current research focusses mainly on soil erosion that is affecting farmland however it is also affecting non-agricultural societies. This research uses a "Model of adoption of soil and water conservation technologies" designed for the adoption of measures in agricultural societies and applies this model in a non-agricultural society. The island of Saba was used as case for this thesis. To be able to analyze to what extent the demands for each of the model's steps were met, literature reviews, interviews and a questionnaire were used. Stakeholders were selected based on their interest and influence, relevant stakeholders are the ones that can contribute, either financially, socially or because they own land.

The application of the steps for adoption on Saba resulted in concrete recommendations, which are expected to be both effective and feasible. The conclusion is therefore that the steps for adoption of soil conservation measures proved to be useful in non-agricultural societies, but seen the differences with agricultural societies an adapted framework is recommended. An extra step evaluating the cause and causer of erosion will help to identify the person or institution that should be held accountable. Extra focus should be put on the collaboration among stakeholders, because separate stakeholders that do not have the available resources, can still succeed when working together. The final step concerning the readiness to undertake measures has been replaced by social capital. This supports collective management of natural resources, crucial for non-agricultural societies where stakeholders need to work together and learn from each other in order to adopt soil conservation measures.

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1. INTRODUCTION

Soil erosion is affecting farmland all over the world, with serious consequences. It has therefore been the subject of numerous studies: from assessments of erosion rates, to counter-erosion measures and their adoption. The introduction of such measures on farmland worldwide has only been partially successful, because adoption regarding soil conservation measures is a complex issue (De Graaff, 1996; De Graaff et al., 2008). This so called adoption of measures has long been of interest for researchers, and multiple frameworks have been developed over time.

While these frameworks almost exclusively focus on soil erosion affecting farmland, soil erosion is also affecting non-agricultural societies. Non-agricultural societies develop where farmland has been left abandoned or where farming was not possible. The share of the world's population that lives in rural areas is decreasing, which results in the land's management being left in fewer hands (World Bank, 2018). The adoption frameworks that have proven to be successful in agricultural societies, might nonetheless provide a basis for adoption research in non-agricultural societies.

This thesis uses the "*Model of adoption of soil and water conservation technologies*" developed by De Graaff (1996) and tested by De Graaff et al. (2008). The different steps within this model are applied to the Island of Saba, a 13 km2 island in the Caribbean Sea under Dutch governance. This island used to be dependent on agriculture until the early 1960's, but has currently abandoned this practice because it stopped being economically viable (interview 3, 6, 10 & 16). The model was used in the quest for suitable and effective soil conservation measures that the islanders of Saba can adopt.

1.1 PROBLEM STATEMENT

The current frameworks for the adoption of soil and water conservation measures have been developed for agricultural societies. However, soil erosion is also affecting non-agricultural societies, abandoned farmland among others. With this research, the suitability of one of these frameworks, namely the model of adoption of soil and water conservation technologies by de Graaff (1996) will be evaluated for non-agricultural societies through the example of Saba.

1.2 CONCEPTUALIZATION

Soil conservation

The adoption of soil conservation measures starts with the measures themselves. Soil conservation as a concept seeks to restore the soils' services that are lost due to land degradation. This implies that successful on-site conservation leads to increased soil fertility, increased biodiversity, cleaner water and air and decreased erosion, thereby increasing the overall production capacity of the soil (Lapar & Pandey, 1999; Dumanski & Peiretti, 2013). This is directly linked to consequences off-site, namely decreased sediment supply, decreased eutrophication of downstream waterbodies and a lower risk for polluted runoff.

Land degradation is naturally occurring and therefore it is not possible to completely stop it, as is described by Morgan (2005) in the following way: *"The aim of soil conservation is to reduce erosion to a level at which the maximum sustainable level of agricultural production, grazing or recreational activity can be obtained from an area of land without unacceptable environmental damage. Since erosion is a natural process, it cannot be prevented. But it can be reduced to a maximum acceptable*

level or soil loss tolerance. This should be considered as a performance criterion that erosion-control measures are expected to achieve (page 152). "

Dumanski & Peirett (2013) discussed the modern concepts within the concept of soil conservation and they concluded that 3 concepts on different levels relate to each other. The concept of no tillage is important at plot or farm level, while conservation agriculture shows to be important at farming systems' level, and sustainable land management at corporate levels. The continuous change in conservation approaches ask for a process of application and adoption, carried out by the stakeholders, rather than the promotion of one specific technology by an third party.

Adoption of soil conservation measures

The process of application and adoption is the core concept for this research. Since the 1950's, this concept has been extensively studied and in its early years it was mainly treated as a binary choice decision process. It was assumed that stakeholders either adopt a recommended technology or not. Lately however, it has become clear that this assumption overlooks the extent and intensity of adoption (Asafu-Adjaye, 2008).

Ervin and Ervin (1982) developed one of the first conceptual models for adoption of soil conservation measures, starting with 3 decision-making process components. This process starts with the perception of the erosion problem. This perception is a product of personal, physical and institutional factors (see *figure 1*). After recognizing the problem, land owners decide whether to adopt a soil conservation measure, this is the second component. At this moment, both personal, physical, institutional and economic factors will influence the decision. Finally, and this is a crucial step for the actual adoption, all four mentioned factors will also influence the soil conservation effort, which is the third and final step. This effort is a function of effectiveness and extensiveness and determines the long-term implementation and maintenance of the conservation measures. A higher conservation effort will lead to higher overall potential productivity benefits in terms of soil fertility and improved yield.



Figure 1Decision-making process for the use of soil conservation practices, from Ervin & Ervin (1982)

De Graaff (1996) has built on the "Decision to use soil conservation practices" from Ervin and Ervin (1982) and developed a model of adoption of soil and water conservation technologies. In the classic theory it was assumed that a rational farm household takes into account the objectives of the farm, the activity options of the farm, as well as its resources and various constraints. However, in more recent years it has become clear that this decision-making process is more complex, especially decision-making for long-term investments like soil conservation. The seven steps of decision making (see *figure 2*) defined by De Graaff (1996) do include these additional aspects. Firstly it should be clear whether farmers recognize erosion and understand its effects. Only when that is the case, farmers will take erosion seriously and undertake soil conservation measures.

Farmers may not recognize the symptoms, if they do not visit their land regularly or if the symptoms appear very slowly and/or are masked by climatic fluctuations. If they have noticed it, they may not know the effects of erosion that led to these symptoms. And when they know the effects they may not consider it serious enough. When they do, they reach the next steps which are focused on the process an individual goes through from first hearing about a soil conservation measure to the final adoption of it (De Graaff, 1996).

More recent research by de Graaff et al. (2008) describes the adoption of new agricultural technologies in three phases, although three different ones from the phases described by Ervin & Ervin (1982) above. Here, within a multi-actor network environment, the adoption process starts with an acceptance phase. This phase includes awareness, evaluation and trial stages and eventually leads to the decision whether to invest in soil conservation measures.

The second phase is the adoption phase in which soil conservation measures are implemented and efforts or investments are made. The adoption reaches then the phase of continued use, whereby soil conservation measures are maintained over many years. This is also the phase where the replication of successful technologies takes place.



Figure 2 The conceptual framework, based on work by De Graaff (1996) & De Graaff et al. (2008)

The third step aims at achieving long-term adoption of these measures, supported by the monitoring and evaluation of the soil conservation measures' effectiveness and their state of adoption. The evaluation can thereupon be fed back to the stakeholders and if found necessary, lead to adjustment of the conservation measures.

Conceptual framework

The starting point of this research is the model of adoption of soil and water conservation technologies developed by De Graaff (1996) and the follow-up by De Graaff et al. (2008). This framework, although developed for use on farm or house-hold level, will be applied to a non-agricultural society, here the island of Saba.

The objective of this research is to evaluate the suitability of the soil conservation adoption frameworks in a non-agricultural society. Furthermore, recommendations will be made for the improvement of the framework for similar situations.

1.3 RESEARCH QUESTION

Taking the problem statement and objective into account, the following research question and subquestions were formulated.

Main research question:

- How can the model of adoption of soil and water conservation technologies be used to assure adoption in non-agricultural societies?

Sub research questions:

- Which soil conservation measures are both biophysically and socio-economically suitable for Saba?
- How does the framework function for assuring adoption of the suitable soil conservation measures on Saba?
- How can the framework be improved for future application in non-agricultural societies?

To answer the questions of this research, a case study research design was used. In this case the research was a combination of a literature review and a social research in the form of interviews and discussions on-site. The study area was from September until December data was collected then. The methodology chapter includes the details of the study area, the different data collection and – analysis methods. The results chapter gives an overview of the stakeholder's state in each step of the model. The discussion chapter elaborates on the results and puts them in a broader perspective, with the help of the recommendations that followed from the model's analysis. In the conclusion chapter these recommendations are used to first evaluate and then improve the model and its suitability in non-agricultural societies.

2. METHODOLOGY

2.1 STUDY AREA

Saba is a volcanic island in the Dutch Caribbean (see *figure 3*), with a peak altitude of 870.4 meters above sea level. This leads to steep slopes, since the island's surface is just 13km². The annual average rainfall on Saba is 760.5 mm at 30 m elevation up to 2000 mm at the top (Freitas et al., 2016). Downwards form the top until the 460 m contour line soil types are ranging from clay loam to very stony loam, and to cherty sandy loam. Further down, the soil formation is not of any significance, since only bedrock is present (Veenenbos, 1955). Most steep slopes on the island are covered by the Eriodendron vegetation. Mount Scenery (500 meters and up) presents, a very well-developed tropical rainforest (Freitas et al., 2016).



Figure 3 Map of the Caribbean, the small Antilles and Saba (Source: nov-orchidee.nl)

The combination of steep terrains, the high amount of rainfall at higher altitude and the poorly developed soil types results in high vulnerability to erosion on Saba. This is enhanced by the free roaming goats on the island. Multiple recommendations for that issue have been made, but no solution has yet to be successfully implemented (Debrot et al., 2011; van der Lely et al., 2014). The increased rainfall variability and more periods of drought will impact the groundwater levels and likely lead to increased erosion in the future (Debrot & Bugter, 2010).

The population of Saba grew in 2015 with 140 residents, leading to the 1,947 residents living on the island in 2016. The working age population is about 1.5 thousand strong, with an unemployment rate of 2.5 percent. Government is the largest employment sector, followed by the construction, education and health care sectors. Agriculture is one of the smallest labor forces, with only 30 employed persons in 2014, thus accounting only for 2% of the economic activity in the country (CBS, 2016).

2.2 DATA COLLECTION

To apply and evaluate the seven steps for adoption, data was collected in multiple ways. To be able to analyze to what extent the demands for each of the steps were met, literature reviews, interviews and a questionnaire were used. Existing literature on the island, erosion and counter-erosion measures are reviewed to gain knowledge on the issue. Interviews and discussions were executed with as little prejudices as possible, the acquired knowledge nonetheless gave some understanding of the situation in order to ask the right questions. Interviews were held to assess the stakeholders' perspective on the current erosion problem and their visions for future land management. Stakeholders were selected based on their interest and influence. Relevant stakeholders were the ones that could have an influence, either financially, socially or because of their ownership of the land. For easier comparison the interviews were structured where possible.

For each of the steps of the model a specific way of data collection and analysis was selected. This will now be explained with the help of the steps:

Step 1: Erosion symptoms recognized?

The first three steps relate to problem recognition and to the stakeholder's perception of erosion. Erosion can be a very slow process and spatial features that indicate the presence of erosion can be unclear to the landowner or relevant stakeholders (De Graaff et al., 2008). Interviews were held with 30 people in total and during most of them questions regarding peoples' view of erosion were asked. This qualitative data was complemented by quantitative data obtained by the questionnaire that was submitted by 42 participants. The following question is an example of which question within the questionnaire was concerned with the first step in the adoption process. This question was asked before and after the presentation about erosion on Saba. Any difference in answers before and after would indicate that the participants were not completely aware of the erosion symptoms.

Please re-order the following environmental problems on Saba (1 being most severe and 6 being least severe)						
Degradation of coral reefs	1					
Droughts	2					
Hurricanes or tropical storms	3					
Invasive species	4					
Overgrazing by goats	5					
Soil erosion	6					

Step 2: Erosion effects recognized?

Solely being able to recognize erosion as a process does not necessarily mean stakeholders know the effects of erosion. This may be due to a lack of education as well as traditional beliefs (De Graaff et al., 2008). To assess whether the effects of erosion are known, the same interviews and questionnaire method was used. This was done by asking people where and how they experienced erosion effects. In the questionnaire this translated to whether people saw soil erosion as a threat to certain features on the island, as shown on the next page. This question was also asked before and after the presentation to evaluate whether the participants' opinion would change when they are better informed.

Additionally, for the second step, an excursion was organized to go into the field with interested residents to talk about the visible and non-visible effects of erosion and give an opportunity to ask questions (*figure 4*).

	strongly agree	agree	uncertain/ not applicable	disagree	strongly disagree
Soil erosion is a threat to Saba's infrastructure					
Soil erosion is a threat to the nature on Saba					
Soil erosion is a threat to the marine park around Saba					
Soil erosion is a threat to Saba's tourism sector					
Soil erosion is a threat to agricultural production on Saba					



Figure 4 The field excursion with local residents (left) and the communal map-making session (right)

Step 3: Erosion taken seriously?

Even though the erosion and its effects are recognized the relevant stakeholders also need to take it seriously. This was assessed during the interviews, during which was asked whether people saw erosion as a serious issue and whether measures were needed in their opinion. This was also done in the questionnaire before and after the presentation with the question on the following page.

Additionally, a map-making session was organized (see *figure 4*), in which the stakeholders had the opportunity to draw the current and desired situation of the area, a research method based on work done by Kessler et al. (2016). Communal mapping attempts to visualize the association between land and local communities. This mapping can help indicate whether people actually would like to see a certain change or not, and therefore whether they take the erosion issue and its effects seriously.

	strongly agree	agree	uncertain/ not applicable	disagree	strongly disagree
Measures are needed to reduce or prevent soil erosion					
More money needs to be invested in these measures					

Step 4: Aware of adequate measures?

The remaining four steps focus on the acceptance of certain soil conservation measures and the possibilities and constraints of their implementation (De Graaff et al., 2008). The first of these steps is the awareness amongst stakeholders regarding suitable and adequate soil conservation measures. For the analyses of this step, interviews were used to assess (1) the current knowledge on conservation measures and (2) the stakeholders' ideas on other suitable measures. The communal map-making session also helped to assess peoples' knowledge on possible measures, since they were asked to draw the desired situation of the area. A drawing of a soil conservation measures is an indicator of awareness regarding these measures.

Step 5: Able to undertake measures?

The fifth step regards the ability of the stakeholders to undertake measures and was analyzed only with the use of interviews. The factors influencing this step are labor and resource availability. The relevant stakeholders for the implementation of soil conservation measures were selected with an *interest/influence matrix*. For each of the stakeholders was asked the following: what is their possible contribution of and need for resources regarding the implementation of measures? This may include the land tenure situation, labor, equipment, financial resources and necessary knowledge. Besides the relevant stakeholders, the local residents were asked for their willingness to contribute to soil conservation by the following question in the questionnaire:

What would you be willing to contribute to possible erosion prevention projects?

(e.g. helping with tree planting, donating money, making your land available for planting, managing sustainable goat populations, etc.)

Step 6: Willing to undertake measures?

Even stakeholders who passed all previous steps might not implement soil conservation measures because of other preferences or socio-economic barriers. The stakeholders' willingness to implement soil conservation measures was assessed in the interviews. The willingness of the local residents to cooperate in soil conservation was assessed using the following questionnaire question:

How would you grade your willingness to cooperate with erosion prevention projects? (Please give a number from 1 (not at all willing) to 10 (very much willing)

Step 7 Ready to undertake measures?

The final step focusses on everything that withhold the stakeholders from adoption even when all steps are passed. This includes additional constraints, risks and psychological thresholds. Even when asked for, stakeholders might not answer this correctly or seriously. The data collection for the analysis required for this step was therefore done mainly unbeknownst to the stakeholders during all interviews, conversations and discussions.

2.3 DATA ANALYSIS

The results of the questionnaire were analyzed with the use of Excel. Each of the questions and their corresponding answers were visualized in graphs. Depending on the type of question, a total average was used, or a simple count of the different answers. The results were used for the classification of the residents and landowners, since they were the main participants of the questionnaire.

The interviews were analyzed in a more qualitative way. At first the stakeholders were identified and represented in an Importance/Influence matrix (see *figure 5*). The stakeholders' importance was ranked based on the effect erosion has on their activities and the economic consequences they face when no action is taken. The Saba Conservation Foundation scored highest since they completely depend on nature areas affected by erosion, both terrestrial and marine. The dive shops, SabaArc, Agriculture Department and Executive Council scored the same because they are all affected by erosion on a daily basis, but do not completely depend on affected areas for their daily activities. The tourism sector and public works department only encounter little consequences from the erosion and the residents, land owners and goat owners are not affected by erosion in their daily activities.

The influence of the stakeholders was ranked based on their resources and power they have to make a change. The Executive Council has the most power and is able to develop and enforce legislation, therefore ranked highest in the matrix. The SCF, Public works, the Agriculture Department and goat owners are all able to change practices in favor of erosion prevention, yet only in their own sector, thus less influence than the Executive Council. SabaArc does not own any land and would therefore first need permission to make a change. The land owners do not have the necessary equipment or knowledge to make a change, although they have the land. Finally, the dive shops, tourism sector and residents can only make a change when asked to help others, they do not have any resources to make a change themselves.

This matrix was used in a later stage of the research to visualize the differences between the stakeholders in each step of the adoption process. For each of the steps the stakeholders got a **positive**, **negative**, **neutral** or a **not** applicable/uncertain label based on the interviews' results. This classification was used in the discussion to identify the main issues for the adoption of soil conservation measures, and thereafter used for the main recommendations towards an improved future approach.



Figure 5 Stakeholder representation in an Importance / Influence matrix

Finally, the erosion risk map (Arendsen, 2017) (see *figure* 6) was used to identify the features at risk on the island. The risk map (see *figure* 9) was combined in ArcGIS with the marine habitat map and with multiple terrestrial layers (buildings, roads, hiking trails and archaeological sites). In a later stage of the research the recommended soil conservation measures were visualized spatially in ArcGIS.

3. RESULTS

3.1 Recognition of the erosion symptoms

The coast mostly consists of cliffs, where landslides and gullies are the predominant erosion processes. Creep erosion is mainly found in the rainforest areas around Mt. Scenery. The soil is almost fully covered but due to the steep slopes signs of creep are clearly visible. Bare tree roots and sloping tree trunks are a common sight. The gullies (locally called 'guts') are clearly visible. Most catchment areas are starting from the top of Mt. Scenery (Arendsen, 2017).

The main stable areas are the villages, the airport and the harbor (*figure 6*). Another stable area is the top of Mt. Scenery, the slopes are less steep and the vegetation cover there is dense.



Figure 6 Map of the erosion risk on Saba. Source: Arendsen, 2017

Half of the coastline consists of cliff-like structures. These areas are described as unstable areas with a very high erosion risk status. They are affected by different types of mass movement, combined with dominant gully networks with a trend to expansion or intensification. Several unstable gullies with a high to very high erosion risk and a trend for local expansion or intensification are found on the island. Also larger unstable gully networks combined with mass movement are located on low to high erosion risk status. A large soil creep affected area is located on the slopes of Mt Scenery. This area has a low erosion risk status and is mainly affected by local gravitational soil creep with a trend to local expansion. The main cause is the steep slopes surrounding the peak.

Heavy mass movement is found on the northern part of the island. These are areas where mass movement is combined with gully erosion, which leads to expansion and intensification. The erosion risk status is, however, low in this part. The same class is found around Old Booby Hill and near the harbor area, next the Fort Bay road. These areas have a high erosion risk status. Also areas surrounding the harbor are indicating dominant mass movement. An area with mainly rill erosion is located beneath The Level and Booby Hill. This area has a high erosion risk status show a trend to intensification and a change to mass movement. Less severe mass movement is located on the east side with a low erosion risk status.



Figure 7 Ranking of environmental problems on Saba by residents

Despite the large scale erosion that is visible on the island and the high erosion risk on the majority of the lower slopes, not everyone recognizes the symptoms of the erosion (as shown in *figure 7*). Before the given presentation on erosion on Saba, soil erosion was on average ranked second most severe after coral degradation. After the presentation, soil erosion was ranked most severe, which can mean that not all the information that was presented was known by the audience.

Most other important stakeholders however, do recognize most of the symptoms (as shown in *figure 8*). Employees of the SCF know where erosion is present (interview 4, 5 & 12), as is the case for government employees working in the Public Works (interview 25) or Agriculture department (interview 1). Goat owners visit the fields and slopes more often than residents and land owners without goats, therefore they tend to recognize the erosion symptoms (interview 15 & 20). SabaArc and the dive shops depend on the land and the waters surrounding the island and therefore a more aware of the erosion symptoms (interview 18). The tourism sector indirectly depends on nature, but is not aware of the erosion issue.



Figure 8 Classification step 1

3.2 Recognition of the erosion effects

It is when the erosion risk is combined with the terrestrial and marine feature that it becomes clear what is actually at risk (see *figure 9*). The buildings are all located in areas with a very low risk. The same is the case for most of the roads, except between Windwardside and St Johns which are potentially prone to undermining, and Fort Bay road which is regularly covered by rocks and sediment.

Archaeological sites, however, are mainly located in high and very high erosion risk areas. This has to do with the preference of the early settlers for easily accessible areas. The director of Saba Archeological Center mentioned damage done to sites on multiple locations. At Mary's point the cliffs are falling apart and calve down towards the ruins. One of the historical cisterns is hanging partly over the edge of the cliff. At Cove bay erosion has filled up indigo vats that were cleared before. At the right side of the Ladder, part of a ridge has come down into the gut. This happened in the early colonial period. One can still find artifacts but the site is practically gone. In the middle of the pirate cliffs, an entrance to an early sulphur mine is visible but impossible to reach since everything around it has come down. The entrance of the actual sulphur mine has been partly filled up a couple of times. Next to the Archaeological sites, many hiking trails around the island experience the effects of erosion, according to Trail Ranger James. One erosion hotspot is located close to the old sulphur mine. More erosion takes place on the, to the Bottom facing, slopes of Bunker Hill and Paris Hill and on the many "guts" on the south side of the island. The North Coast trail and the Sandy Cruz trail, both on the north side of the island, are very prone to erosion.

This was acknowledged by Jenny working for the Saba Trail Shop. Furthermore she mentioned a large landslide close to the sulphur mine, just behind a couple of houses in Hell's Gate. The house owners have been scared by that landslide so close to their houses and are afraid that it might move closer over time. Saba Marine Park manager Kai Wulf indicated similar places where hiking trails are damaged by erosion caused by natural processes and by human actions. One example of the human actions is Tent Bay, where sand was disposed of after emptying the harbor. It was known that it formed a risk for the reef next to it. A replacement request was written, but the sand has never been completely removed. During the past hurricane large parts of it disappeared into the sea. Parts of the North Coast trail have been rebuild several times because of erosion, but this happened in very remote locations which are hard to reach with vehicles and machinery.



Figure 9 Map of the erosion risk on Saba and the terrestrial and marine features at risk. Based on work by Arendsen (2017)

An additional location where the effects of erosion are clearly visible is the Spring Bay dump site. The water destabilizes this dump area, which is located in a steep gully. The construction worker that was present indicated that this regularly causes debris slides, and the material eventually will flow into the ocean at Spring Bay. Soil, construction waste and organic waste is dumped, but not compacted. This means that the material is very loose and water can easily turn it into mud. When oversaturated, the material will slide into the gully. Senior policy advisor Menno van der Velde confirmed that with heavy rainfall this material erodes away and flows down in the direction of Spring Bay.

Far more important is the effect of erosion on marine life. The transport of eroded material in general continues until it reaches the ocean or a lower-lying area from which the material cannot move. On large continental areas this can take up to hundreds of years, but on a small and steep island like Saba this can already happen in a matter of hours. Especially the small clay to silt fraction reach the ocean in a short amount of time, staying mostly within a one kilometer radius, as was observed at the Great Barrier Reef (Bartley et al., 2014). The marine habitat map of Saba (see *figure 9*) shows that all of Saba's reefs, coral reefs, macro algae and seagrass fields are located within this one kilometer zone, making it vulnerable for sedimentation.

Sedimentation is a crucial process for marine life, for it supplies the necessary nutrients. However, increased sedimentation and eutrophication affect coral reefs worldwide (Brodie et al., 2012). According to Fabricius (2005) terrestrial runoff affects coral reefs in four fundamentally different processes. The first process is the reduction of coral calcification and fertilization rates due to dissolved inorganic nutrients. The second process is the provision of a growth advantages for organisms other than corals because of enrichment by particulate organic matter. This causes unfair competition and has therefore negative effects on coral populations. The combination of organic and inorganic matter causes light limitations due to turbidity. This leads to the third process is the direct sedimentation on top of the coral, thereby smothering the organisms and reducing its growth and survival.



Figure 10 Rating of erosion as a threat to Saba before and after the presentation

All of this was acknowledged by the majority of the questionnaire participants as shown in *figure 10*. Soil erosion was rated as a threat to agriculture, tourism, the marine park, nature in general and to infrastructure. However, after the presentation the questionnaire results turned out differently. The

effects of soil erosion were rated higher, implying that their initial recognition of the erosion symptoms was not complete.

Based on the questionnaire results and especially the significant difference between the two, the residents and landowners get a negative classification (*figure 11*). *Figure 10* additionally shows that the marine effects of erosion were most underestimated. The SCF, SabaArc and the dive shops fully recognize the effects of erosion on their area of operation (interview 12 & 18). For the other stakeholders this is not fully the case.

Importance			Saba Conservation Foundation	
	Diveshops	SabaArc	Agriculture Department	Executive council
	Tourism sector		Public works	
	Residents	Landowners	Goat owners	
•				Influence

Figure 11 Classification of step 2

3.3 SERIOUSNESS OF EROSION

Tieskens et al. (2014) assessed the value of the ecosystems on Saba (*figure 12*). Concluded was that there is a sharp contrast in values, both terrestrial and marine. The greatest economic value can be found on top and along Mount Scenery and on the beaches on Wells Bay and Cove Bay. The values on top of Mount Scenery can rise up to 20,000 US\$ per hectare per year. This is because many tourists come to the island for a single day, they hike up the volcano and leave. Going to the beach is not a prime reason for tourist to visit Saba, but they make use of these ecosystems. According to Tieskens et al. (2014) conservation of these ecosystems should have high priority on Saba considering the recreational activities in those areas.

The marine value is clearly higher than the value of the terrestrial areas. On some points this value exceeds 200,000 US\$ per hectare per year. The coral reefs not only protect the island from the sea, it also provides good fishery grounds and snorkelling and scuba diving opportunities. The coral reef areas are immensely important to the economy of Saba and should be maintained in the best conditions at all costs.



Figure 12 Total economic value of Saba. Based on Tieskens et al. (2014)

The total economic value of Saba's natural environment is highly concentrated on relatively small areas. Soil erosion on specific valuable places could therefore be devastating for the island's economy. Although, there are several policies in place to manage the areas with high economic value, there is no authority that is in charge and responsible for the conservation of certain of these economically valuable natural areas. To guarantee the sustainability of the concentrated economic value on Mount Scenery, the management of this area should be strongly embedded within the institutional framework of local spatial policy. The current zoning of the Saba marine park is concurrent with the spatial distribution of economic value. However, some reefs which add a significant value to the economy of Saba are located within the less protective zoning of 'multipurpose'. A slight alteration to the zoning including this area in the 'no take' zoning could provide optimal protection of the coral reef and thus retain the economic value of the marine park (Tieskens et al., 2014).



Figure 13 Rating of the need for measures and investments against erosion

Seeing the serious economic consequences of erosion on Saba, one would expect a high degree of seriousness towards the subject of erosion. This is in fact reflected in the questionnaire results as presented in *figure 13*. The increase of seriousness after the presentation emphasizes the usefulness of awareness raising. The majority of the residents and landowners that participated in the questionnaire regard measures and investments necessary to counteract erosion. Yet little has been done in the past to counteract erosion. The SCF, Agriculture Department and Public Works have implemented some soil conservation measures in the past, but on very small scale.



Figure 14 Classification of step 3

All three institutions have other priorities. The SCF has a larger focus on marine nature since they depend on the fees from divers and yachts (interview 12 & 17). Randall Johnson, head of the Agriculture Department indicated that their current priorities are combating rats and mosquito plagues,

with a smaller focus on the production of vegetables and the selling of seeds (interview 1). The department is planning on planting different trees around the island as erosion protection measures. For these reasons the two departments and the SCF get a neutral classification for this step (*figure 14*). The executive council, as responsible government body is not taking erosion serious enough seen its importance for the island's economy, and this warrants the negative label. Goat owners do not want to change their way of working and also get a negative classification (interview 19). The dive shops and SabaArc do what is possible regarding their limited resources and do take erosion seriously, they get a positive classification.

3.4 ADEQUATE MEASURE AWARENESS

To counteract erosion, soil conservation measures can be used. These measures are based on the idea that preventing erosion is better than curing it. Soil conservation is based on four basic techniques (Morgan 2005; Kuypers, Mollema & Topper, 2005):

- Providing soil cover for raindrop protection,
- Increasing the soil's infiltration capacity to reduce runoff,
- Improving the aggregate stability of the soil and
- Increasing the surface roughness to slow down runoff.

This implies that successful on-site conservation leads to increased soil fertility, increased biodiversity, cleaner water and air and decreased erosion, thereby increasing the overall production capacity of the soil (Dumanski & Peiretti, 2013). This is directly linked to positive results off-site, namely decreased sediment supply, decreased eutrophication of downstream waterbodies and a lower risk for polluted runoff. Land degradation is a naturally occurring and therefore it is not possible to completely stop it but it can be reduced (Morgan, 2005).

For implementation of soil conservation measures on Saba the erosion processes and risk maps were used to categorize the different erosion problems. These different categories need a different soil conservation measures each. Together with the stakeholders the most feasible measures were selected and presented in a flowchart (see *figure 15*) and spatially visualized as a map (*figure 16*).



Figure 15 Soil conservation measures for Saba. Based on stakeholder discussions and Morgan (2005) & El-Swaify et al. (1982)



Figure 16 Locations of the recommended soil conservation measures for Saba. Map is based on work by Arendsen (2017)

Based on the conversations and discussions that led to the development of the *Erosion prevention plan for Saba* (see *Annex 1*) it became clear that there is much knowledge on adequate measures. Both the SCF and the two relevant government departments are aware of a large set of measures suitable for Saba, the same is the case for SabaArc (interview 1, 12, 18, 25 & 27). However, stakeholders that were not directly involved in land management and implementing soil conservation measures showed a lower level of awareness regarding adequate measures (*figure 17*).



3.5 ABILITY TO UNDERTAKE MEASURES

The most limited resource as indicated by most stakeholders is labor. Kai Wulf of the SCF indicated that it is the most difficult aspect to assure on Saba (interview 12). The younger generations do not want to work on the land. Only one of their employees is working on terrestrial nature at the moment. Individually, none of the stakeholders is able to fully address the erosion on Saba. Without collaboration they are not ready to undertake serious measures, because they separately do not have the necessary equipment, knowledge or labor force. However, together they are able to undertake measures and that is why the SCF, Agriculture department, Public Works and SabaArc do get a positive classification.

The land tenure is often unknown and difficult, but after consultation using other people's land seems to be possible. Senior policy advisor Menno van der Velde confirmed this by stating the following: *"Mediation between project proposers and possible landowners has been, and will be, the way to achieve change in land management on Saba"* (interview 13). Russell Thielman sees it that way as well, he stated that people are very willing to cooperate when they see that it is necessary or important (interview 25). For example the road had to be widened in some places and that was no problem. The same for planting trees, that is only improving the land and he does not expect problems with that.

More financing is necessary for the implementation of soil conservation measures, but it is possible to receive these funds. Local government would first need to be informed properly and for funding from the Netherlands a solid plan needs to be developed. Based on that, the Executive Council would be able to undertake measures, however, the Saban attitude towards the government is quite skeptical. As Menno van der Velde mentioned, mediation is needed and top-down legislation does not work. That is also noticeable in the failure of past projects like the Goat Buy-back, where the government could not enforce the promised legislations. It is therefore that the Executive Council does not receive a positive classification, they lack the necessary law enforcement.



Figure 18 What people would be willing to contribute to soil conservation projects

The residents and landowners are able to contribute to the implementation of measures. They are especially eager to plant trees as shown in *figure 18* and some of them can contribute land, finance or management. This reflects itself in the positive classification as shown in *figure 19*. The goat owners however, do get a less positive classification since they often do not have the financial or material needs to manage their herds properly (interview 2, 14 & 20).



Figure 19 Classification of step 5

3.6 WILLINGNESS TO UNDERTAKE MEASURES

Nearly all stakeholders indicated that they are willing to undertake soil conservation measures. In *figure 20* the residents' willingness to cooperate is shown, which is quite high. The vast majority of the participants graded their willingness above 5 and many graded 8 or higher. The SCF, the government departments and the executive council agreed upon the recommended measures as presented in *Annex 1*.



Figure 20 Participants grading of their willingness to cooperate

Additionally, SabaArc, the dive shops, the tourism sector and the residents are positively classified for their willingness. The latter, showed a very high willingness to cooperate as is presented in *figure 21*. Individual land and goat owners showed a less positive willingness to cooperate. They want to continue with their century old practices. Randall Johnson mentioned that originally goats are a backup food source during difficult times, but that has changed: "You would expect that 2 category 5 hurricanes are about as worse as it gets, but none of the goat owners has slaughtered and sold more goats than they normally would" (interview 19). This is predominantly because none of the goat owners depends on their goats for their livelihoods. All of them do have another job as main income source.



Figure 21 Classification of step 6

3.7 READINESS TO UNDERTAKE MEASURES

In non-agricultural societies the risk factor is not really present since it is not farmers that have to invest in material in order to build measures and no one depends on the land for their livelihoods. The fact that little to none happened in the past to reduce erosion on Saba, despite the present awareness and knowledge, does say something about the absent readiness of the stakeholders

What became clear from the interview with Will Johnson was that agriculture is something from the past, also related to a history of slavery in the Caribbean (interview 10). That has led to a current distancing from land management, which increases the difficulty to implement soil conservation measures. Kai Wulf confirmed this by saying that it is very difficult to find employees for physical labor outdoors (interview 12).

4.DISCUSSION

Before discussing the results it is important to describe the limitations of the research. Upon arrival at the research area, two major hurricanes struck the island. This lead to an abnormal daily life for many islanders, which potentially influenced their thoughts about erosion as a problem to the island. This might also have influenced the amount of people that took the effort to come to the presentation, excursion and map-making session. Many islanders simply had other priorities due to damaged property and a disrupted community.

The low amount of participants during the presentation expressed itself in the results of the questionnaire, which are not significant. Furthermore, only the people that already were aware if the erosion and that saw it as a significant threat came to the different activities. This might have caused a positive overestimation for the different steps of the framework.

According to De Graaff et al. (2008) the acceptance of soil conservation measures will theoretically happen when the involved stakeholders have passed through most or all of the seven steps, depending on their situation. In the previous chapters, these steps were applied to the stakeholders of the erosion issue on Saba. None of the steps where passed by all of the stakeholders, which means that multiple aspects in the adoption process lack.

Awareness and knowledge lacks in the first four steps. The erosion symptoms are recognized by most of the stakeholders, but the effects, especially the marine ones, are unclear to many. Despite the high economic consequences, erosion is only taken serious by few. Furthermore, only the SCF, SabaArc, the Agriculture department and Public Works are aware of adequate measures. A top-down approach does not work, policy and legislation is very difficult to make and enforce on Saba. It is therefore difficult for several parties to undertake effective soil conservation measures. On the other hand, the willingness to undertake measures is high and many people and institutions can contribute in some way to the implementation of measures. Unfortunately, goat owners show very low willingness to help, because they believe that the change will not benefit them.

Based on the bottlenecks that have been exposed by applying the steps for adoption, the following approach is recommended for Saba:

- Awareness raising for the entire population and Nature education in (high) school, this can increase the willingness to cooperate and will help to achieve a bottom-up approach
- Informing the Executive council on erosion and their role in policy making and enforcing
- Developing a guide with best soil conservation practices and the right locations to implement those
- Ensure cooperation between the Conservation Foundation, Agriculture Department and Public Works to combine resources
- Focus on sustainably managed goat population that benefits goat farmers as well
- Use the local people interested in helping (e.g. tree planting) to compensate for the lack of labor

This is very much in line with the conclusions drawn by De Graaff et al. (2008) who emphasizes the importance of awareness raising. Furthermore they conclude that the implementation of soil conservation measures should not be done on its own, but always be accompanied with wider measures and motivating activities that improve the future prospects of increasing income. This is taken

into account in the recommended approach. The seven steps worked for empirical studies in the research of De Graaff et al. (2008) and in general they resulted in realistic and case specific recommendations.

However, and this is of great importance for this research, the previous studies took place in agricultural societies. To test the suitability of the framework in a non-agricultural society, it was applied to the Island of Saba with very different circumstances and boundary conditions. It is therefore necessary to look into the differences between this case study and the situation from which the original framework originated and the ones in which it was previously applied. Originally, the framework was named *"Farm level decision making in relation to soil and water conservation"* (De Graaff, 1996). Although the name changed over time, the focus continued to be on farm level decision making. This approach is suited for agricultural societies where the major decisions about land management are taken by the head of the household or through a consensus among household members (De Graaff, 1996). In non-agricultural societies on the other hand, the major decisions about land management are taken by a combination of stakeholders that is unique for each situation.

This manifests itself in the first 3 steps of the framework, in which problem recognition and perception of erosion is crucial. In an agricultural society it is clear who is responsible for which land area. This includes activities on and visits to the fields, as well as insight in the yields over the years and thereby insights in the state of the soil and the effects of erosion. This was confirmed by Hudson (1981) by stating that both small and large scale farmers are experienced and efficient in land husbandry and that land damage through ignorance rarely is the case. Additionally, in agricultural societies erosion affects the farmers' fields and that makes the user also the direct victim of it. This is different for non-agricultural societies where it occurs that land areas do not have a clearly defined owner, let alone a regular user. The off-site nature of the erosion problems on Saba makes it even harder to determine the exact cause. That makes it difficult to hold the causer of the erosion accountable for the implementation of soil conservation measures.

Land users, active in an agricultural society, are expected to be knowledgeable and experienced in land management and somehow aware of soil conservation measures (step 4). Land owners who do not use their land directly and do not have employees that do so, are less aware of adequate measures, as we saw in the Saba case. That emphasizes the need for more awareness raising in non-agricultural societies, compared to similar situations in agricultural societies.

In agricultural societies, soil conservation measures are an extension of the farmers' usual activities on the field and do not necessarily demand extra resources in terms of equipment and knowledge on land management. However, in non-agricultural societies, equipment and knowledge might lack completely. It could therefore be more difficult to gather the needed resources, but the Saba case showed that in some situations the stakeholders do have the resources that are needed when they work together. Collaboration among stakeholders is therefore more crucial in non-agricultural societies.

The next step in which the willingness to undertake measures is analyzed focusses mainly on socio-economic barriers to invest. Off-farm income plays a role in the failing of adoption in agricultural societies, but in non-agricultural societies this is the normal situation. The same counts for the difficulty to find a successor in agricultural societies.

The final step in the adoption process is less relevant for non-agricultural societies since the land owners do not depend on the land for their livelihoods and therefore the risk factor is absent. The Saba case showed that despite present knowledge, experience and material resources little to none has happened in the past regarding soil conservation measures. This corresponds with what Hardin

(1968) called "the tragedy of the commons". This tragedy expressed itself in the Saba case in the following way: stakeholders do use natural resources, but the costs of the exploitation does not come back to them. This is similar for non-agricultural societies where there is a large gap between the "causer" and the "sufferer" of erosion problems.

This lack of taking responsibility can be changed by the resource users themselves. Orsom (2008) describes how resource users develop effective institutions for regulating the common resources. The likelihood that this will happen is increased by multiple factors of which social capital is the most important one. This includes similar interests among stakeholders, low costs of inter communication and low costs of reaching binding and enforceable agreements (Orsom, 2008).

Pretty (2003) concludes that the social capital lowers the costs of working together and facilitates cooperation. Exactly this cooperation, or collaboration, is what lacked in the Saba case. The interviews indicated that strict regulation or enclosure is not a viable option for the island and therefore improving social capital can lead to collective management of natural resources, in this case the implementation of soil conservation measures. To reach collective resource management it is necessary to build trust, develop new common norms and help to form groups.

Ravnborg & Westermann (2002) emphasizes the need of joint learning among stakeholders in collective natural resource management. They state that individuals might not be explicitly aware of the transboundary implications of their actions, even though biophysical interdependencies are well recognized. This represents itself on Saba in the fact that the erosion problem and the effects are relatively well understood and recognized, but that it is not taken serious despite the natural and economical consequences. Stacey MacDonald confirmed that by saying that educational campaigns for and information sessions with the local community often go a long way, especially when supported by the government. She would always advice organizing public information sessions that allow for debate on the issue and involve the ideas or knowledge of the community (interview 22).

Although the Saba case is like no other situation, collective resource management supported by social capital has proven its effectiveness, both in agricultural and non-agricultural societies (Pretty, 2003; Pretty & Smith, 2004).

5. CONCLUSION AND RECOMMENDATIONS

In this research the suitability of the model of adoption of soil and water conservation technologies has been analyzed for the adoption of soil conservation measures in a non-agricultural society. The steps in this adoption process have been applied to the Island of Saba in the Dutch Caribbean. The application of the steps for adoption on Saba resulted in the aforementioned recommended approach, which is expected to be both effective and feasible. The conclusion is therefore that the steps for adoption of soil conservation measures proved to be useful in non-agricultural societies.

However, seen the differences with agricultural societies, in particular the lack of a clear cause of erosion and a responsible party, an adapted framework is recommended (see *figure 22*). In addition to the first three steps regarding problem recognition, a fourth step has proven to be necessary, namely the cause and eventual causer of erosion. This is often clear in agricultural societies where erosion causes more on-site problems and where farmers and natural processes are the only causers, but might not be so clear in non-agricultural societies. This will help to identify the person or institution that can be held responsible, something that lacked in the original framework.

Based on the outcome of the second and third step, additional and/or different stakeholders should be taken into account. In the fifth step concerning ability more focus should be put on the collaboration among stakeholders. The Saba case study showed that although separate stakeholders might not have the available resources, they still can succeed when working together.



Figure 22 Improved framework for application in non-agricultural societies

The final step concerning the readiness to undertake measures appears to be irrelevant, since the risk factor does not play an important role in non-agricultural societies. This step has therefore been replaced by the presence of sufficient social capital to undertake soil conservation measures together. This additional step supports collective management of natural resources, crucial for non-agricultural societies where stakeholders need to work together and learn from each other. Improving social capital would not only be beneficial for Saba, but for all non-agricultural societies where responsibility is not, or cannot, be taken by a government body.

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ANNEXES

1. EROSION PREVENTION PLAN FOR SABA

Based on the interviews conducted, the erosion awareness questionnaire, field trips and literature research, the following measures are found to be suitable and recommended for Saba:

- Awareness raising on the erosion causes and problems is needed (*for example see infographic next page*). Communal tree planting will involve the people that are aware and will assure the needed manpower. Nature education at school (e.g. geography class), by Junior Rangers and Snorkel club programs, by Child Focus and by Sea & Learn should be encouraged to involve younger generations in future nature conservation.
- Maintain current forest areas to assure soil cover for the future, especially close to vulnerable areas and buildings. Oblige minimal disturbance of the soil cover in new construction projects
- Avoid concentrated outflow of water from the roads, gradually diverting the water leads to less erosion. This is especially needed for the water going from the Level to Booby Hill and at the lowest points of The Road.
- Reduce grazing pressure to assure natural regrowth of vegetation, which is well adapted to local conditions and more biodiverse than technical restoration.
- Reducing grazing pressure to 0.1 goat per hectare is expected to be difficult to maintain on Saba. It is therefore recommended to help goat owners to fence all of their goats and to use off-island hunters for the final eradication of the free roaming ones. Small fenced areas can be used as an example for goat owners.
- With good grazing management, tree planting is only necessary at high risk areas. This is around Cove Bay, along the road between St Johns and Windwardside, along the Fort Bay road and along the road to the landfill. Fruit and nut trees can contribute to local food production.
- Rock check dams will slow down the water and catch the sediment in gullies accessible by machinery. This is needed in the gut next to the Fort Bay road and the gully from St Johns to the landfill. Rocks are locally available and grass barriers will enforce them and help catch finer sediment.
- Vegetative barriers are needed in gullies inaccessible by machinery, the Tent Bay gut and the Cove Bay gut have priority given their marine and recreational value respectively. Local grass species are suitable and vetiver grass can be a good addition, since this species is non-invasive, very strong and grows in Saba's climate.
- Grass barriers should be used to strengthen hiking trails, especially right after maintenance when the soil cover is disturbed.
- Grass cover is needed for the dumpsites in the Spring Bay gut, on the Tent Bay road, around the stone quarry and on future construction sites. Organic material should be used for mulching, shredded trees add nutrients to the soil for fast regrowth of vegetation and intercept the rain, thereby avoiding splash erosion.

Soil erosion and prevention on Saba



Erosion is the natural transport of rock, sand and clay. Enhanced erosion, by human intervention, is something we need to prevent.



Naturally, vegetation would re grow after a drought, forest fire or hurricane, thereby protecting the soil from eroding away.



Due to overgrazing by goats and changes in soil cover by humans, this is not happening everywhere on Saba.



The nature of Saba and its dive sites and hiking trails are the main reason for visitors to come to the island. Erosion will thus indirectly affect the island's economy.

Frosion in the form of landslides and rock fall leads to damage and dangerous situations on hiking trails.



Archaeological sites get filled up by sediment like the indigo vats at Cove Bay or are washed away like some houses at Mary's Point

Erosion risk categories for Saba

Loose material on dump or construction sites gets easily removed by rain and washes away. This is happening in the Spring Bay gut and at the landfill

ery hig hiah very low

All eroded material eventually reaches the ocean. When this is too much, this causes damage to coral reefs and poor visibility for divers

Heavy rainfall leads to excessive water on the roads and rock fall leads to damage and blocking, for example at the Fort Bay road

Planting trees, shrubs and grasses is the most effective and most beautiful option for places where erosion is a problem. The plant's leaves intercept the raindrops and the roots hold the soil.

Planting trees can be a fun and interesting nature education activity, perfect for an island wide action. For example on Earth Day





Want to help?

Follow the SCF facebook page (@sabapark) for updates on activities or reach out to the **Agriculture Department** for the purchase of plants When erosion

Rock fall

damages

causes dangerous

beaches and

situations like

at Well's Bay



Smaller and better managed goat herds help vegetation to regrow naturally and secured fodder availability will lead to larger goats and higher meat quality



Many trees and shrubs produce fruits, nuts or edible leaves too. This increases local food production and is beneficial for many types of birds and insects.

Designed by Jesse Opdam as part of his master's thesis for the International Land and Water management program of Wageningen University, the Netherlands. December 2017 The erosion risk map was made by Pim Arendsen (2017) and the preventive measures are adapted from Morgan (2005) and El-Swaify et. al (1982)

Arendsen, Pim. (2017). Mapping erosion on Saba: How to keep the Unspoiled Queen from tumbling down. (Bachelor's thesis)
El-Swaify, Samir Aly, Edgar W. Dangler, and Clinton L. Armstrong. "Soil erosion by water in the tropics." (1982).
Morgan, R. P. C. (2009). Soil erosion and conservation. John Wiley & Sons. WAGENINGEN

Awareness raising

The evaluation of the first 4 steps of the model showed that awareness raising on erosion and its consequences and solutions is needed on Saba. This could be done by organizing educational campaigns for and information sessions with the local community, thereby organizing public information sessions that allow for debate on the issue and involve the ideas or knowledge of the community.

Communal tree planting will involve the people that are aware and will assure the needed manpower, at the same time providing a more hands-on way of awareness raising. Nature education at school (e.g. geography class), by Junior Rangers and Snorkel club programs, by Child Focus and by Sea & Learn should be encouraged to involve younger generations in future nature conservation. This will increase the willingness to cooperate and will help to achieve a bottom-up approach rather than the enforcement of top-down legislation.

Maintaining current soil cover

Maintain current forest areas to assure soil cover for the future. Oblige minimal disturbance of the soil cover in new construction projects. . It is recommended that average ground cover levels are kept at or above 75% to reduce hillslope runoff (Bartley et al., 2014).

Removal of vegetation in humid climates will lead to greater rises in erosion rates than removal of vegetation in drier climates. Forests in humid climates have a very high degree of protection, but on the other hand the erosive capacity of high rainfall is much larger to. Which results in higher erosion rates when vegetation in these area is removed (Morgan, 2005).

Avoid concentrated outflow of water from the roads, gradually diverting the water leads to less removal of soil cover which eventually causes erosion. This is especially needed for the water going from the Level to Booby Hill and at the lowest points of the road.

Grazing management

Free roaming goats have been a problem for a long time on multiple islands in the Caribbean (van Buurt & Debrot, 2016; Freitas et al., 2016; Debrot et al., 2011; Debrot & Bugter, 2010; Campbell & Donlan, 2005 and Coblentz 1980).

"Our field data show that most wilderness areas of Saba remain strongly affected by roaming grazing goats even though the contribution of goats to the local island economy is negligible. Goat dung or traces of grazing were recorded in or adjacent to 46% of the sample plots. Grazing by exotic mammals reduces the resilience of natural vegetation types and interferes with natural succession. Highest livestock densities and impacts seem to be in the more vulnerable coastal arid zones along the western and southern sections of the island with poor soil conditions and more open and shrubby vegetation (Freitas et al., 2016)"

Reducing the number of goats is a very effective way of assuring regrowth of vegetation. This is because a lower grazing pressure gives opportunity to plants to colonize new areas. The natural succession is no longer stopped or slowed down. Research into natural succession of plant species showed that this reliable for stabilizing slopes (Osman, N., & Barakbah 2011). In Central Europe natural succession showed promising results, especially on small disturbed areas that are still surrounded by natural vegetation. Natural succession has advantages over technical restoration because of the following reasons: colonizing species are well adapted to the local conditions, the natural value in terms of biodiversity is higher and natural succession is cheaper (Prach & Hobs 2008; Prach & Pyšek, 2001). In Puerto Rico, with a climate more similar to Saba's, natural succession showed promising results as

well, with the establishment of pioneer shrubs and grasses within a year (Walker et al., 1996). Freitas et al. (2016) conclude that the development of woodland on the less-grazed northern side of the island suggests that the southern and western coastal zones should have potential for woodland regrowth when the grazing pressure is reduced

To assure this natural succession to combat erosion, goat numbers would need to be brought down to a sustainable level. Research in Washington Slagbaai National Park of Curacao and Arikok National Park of Aruba showed that natural regrowth will occur when free roaming goat numbers are equal to or less than 0.1 per hectare (Veerbeek, 2016; Van Buurt & Debrot, 2012). That would imply a maximum of 131 free roaming goats on Saba. However, since only the lower slopes are inhabited by goats, maximum numbers are reduced to 74 free roaming goats.

Previous projects to reduce the number of goats have been successful, but only for the time being. The buy-back programs of 2004 and 2014 brought down the population, but existing island legislation has not been enforced after the programs, leading to quick regrowth of the goat population. This asks for a more long term approach with a continuous enforcement of legislation. Freitas et al. (2016) acknowledge that by stating that island-wide projects on Saba failed because of lack of support and that a phased approach is needed in the future. This approach would need public awareness campaigns and demonstration projects combined with strong political will to address the problem.

Different goat owners and hunters indicated that selling the meat on Saba is very difficult, which means that most herds are just roaming free without close attention of the owners. On the other hand, the three goat owners that have their goats fenced off, have larger goats, are able to prevent inbreeding and do sell a higher quality goat meat. Supporting goat owners that are willing to fence their goats and to manage their herds might therefore be beneficial for both the owners and the land.

Based on conversations with hunters, goat owners and previous research done by Freitas et al. (2016) Campbell & Donlan (2005) and Van Buurt & Debrot (2012) the following grazing management is recommended for Saba:

- Establish the enforcement of existing island legislation regarding livestock
- Fence off areas with very high priority and use those areas for awareness raising
- Actively support goat owners who want to fence their own goats
- Give owners of fenced goats permission to use the grass hedge trimmings as animal fodder
- Organize a new Goat Buy-back program for all free roaming goats that are left

Planting trees

Large areas that are currently used as grazing land used to have trees and it is recommended to reintroduce them to these areas for the reduction of erosion. Besides good grazing management what will enhance the natural regrowth, planting trees would be a very effective option. The Agriculture Department is currently planting trees along the Fort Bay road to reinforce the side of the road. This practice should be implemented on a larger scale in multiple areas. This should be done in places where erosion is an actual risk for places on the island; around Cove Bay, on both sides of the road between St Johns and Windwardside, along the Fort Bay road and on the seaside of the road to the landfill. Suitable plants should meet the following criteria (based on Morgan, 2005):

- Have rapid growth
- Have an extensive and deep root system
- Are tough in respect of diseases and pests

- Able to compete with less desirable species
- Adaptable to the local soil and climatic conditions
- Ideally be local, to avoid introduction of invasive species

A number of suitable tree species can already be found on the island: Sea Grape, Mango, Avocado, Mahogany and the Flamboyant tree. Additionally, Moringa could be used, which is suited to areas

where strong winds and long, dry spells occur simultaneously. This extremely fast growing tree offers many food and non-food products (Orwa et al., 2009)

Currently, planting trees needs to be combined with wired fences to protect the young trees from free roaming goats. With better grazing management this might not be always necessary, which will reduce the costs significantly.

Rock check dams

In the gullies accessible by machinery rock check dams will reduce the water flow velocity and catch the sediment. Rocks are locally available and the dams are easy to install. This should be done in the gully along the Fort Bay road and in the gully up from the land fill towards St Johns. *Figure 1* shows an example of such dams and *figure 2* shows the front and side view of these dams. The area behind the dam will eventually fill up with sediment, thereby



Figure 1 Example of rock check dams in a gully

shortening the length of the slope which leads to a decrease in the water's flow velocity and a decrease in further erosion of the gully floor (Kuypers, Mollema & Topper, 2005).

The following points should be taken into account for the construction of rock check dams (Kuypers, Mollema & Topper, 2005; Morgan, 2005 and El-Swaify et al., 1982):

- The rock dam needs good anchoring into the gully walls to prevent washing away of the sides (*figure 2*)
- The rocks need to be placed under a graded slope of preferable 2:1 (2 meters wide by a height of 1 meter) to minimize the chance of breaking
- The dam should be lowest in the middle to support overflow without risking damage of the sides.
- The gully floor downstream of the dam should be strengthened by concrete lining to prevent scouring and eventually undermining of the dam. The rock dams should be strengthened by vegetative barriers



Figure 2 Front and side view of a rock check dams, strengthened with grass

Vegetative barriers

In gullies inaccessible by machinery vegetative barriers should be used to slow down the erosion and to catch fine sediment. This is especially needed in the Tent Bay gut, seen the importance of marine life in the Tent Reef area. Additionally, vegetative barriers are needed in the gut going from Hells Gate to Cove Bay, because of the recreational value of that area.

There is an abundance of different grass species on Saba (Freitas et al., 2016) and many could be used for these barriers. Based on one of the interviews, vetiver grass appears as a very suitable plant. The interviewee had positive experiences with the grass in the climate on Saba. The introduction of the non-invasive Vetiver grass could be interesting for the development of vegetative barriers

A dense closed barrier of vegetation prevents sediment from flowing downstream. The buildup of material behind the barriers decreases the slope of the gully floor and thereby reduce the velocity of the water flow. The following points should be taken into account for the construction of vegetative barriers (USDA, 2012; Truong, Tan Van & Pinners, 2008); Kuypers, Mollema & Topper, 2005; Morgan, 2005):

- The barriers should be placed perpendicular to the gully (see *figure 3*)
- The barriers need to be established before the wet season, to prevent washing away of the plants
- Plants should be placed 10 centimeters apart and in double rows for optimal establishment

The same principle should be applied to hiking trails that are damaged by erosion. During the rebuilding of the trail, rows of vegetation should be planted on the sides of the trail. This retains the soil and reduces the damages from water flowing over the trail (see *figure 3*)



Figure 3 Example of vegetative barriers in a gully and on the sides of a hiking trail

Cover plants

Bare soil or rock is very prone to erosion, this can be reduced by providing a soil cover. To assure both short and long-term development of cover plants, grasses and shrubs should be combined. The grass will protect the slope against erosion by raindrop impact and runoff, and also trap moving sediment and the shrubs retain the deeper soil by their root system. This is especially needed on the dumpsite in the Spring Bay gut and at Tent Bay. Additionally, future construction or dump sites would need the same treatment.

Suitable plants meet the following criteria (based on Morgan, 2005):

- Able to survive in the climatic and soil environment
- Ideally be local, to avoid introduction of invasive species
- Have a short or prostrate growth form
- Have flexible rather than brittle or rigid stems and leaves,
- Have basal or underground growth points,
- Have rapid growth
- Able to withstand burial by soil and rocks
- Able to withstand exposure of the root system.

Multiple suitable species do already grow on Saba: hurricane grass, guinea grass and elephant grass. Additionally, vetiver grass as described in section 5.5 could be used.

Vegetation increases the infiltration of water into the soil, but this can cause problems where rainfall amounts and intensities are very high. Where soil saturation is a danger, the vegetation may need to be supported by a drainage system that diverts the water (Morgan, 2005). This would be recommended for the Spring Bay gut dump site. Diverting the water through a by-pass would reduce the risk for landslides on the dump site, making it safer for all people that visit the site.

Mulching

Next to soil and construction debris, organic material is dumped in the Spring Bay gut, at the Fort Bay landfill and in the gut going from the Bottom to Fort Bay. These cut trees and bushes are perfect for the development of a mulch layer. Entire trees take a long time to decompose and do not completely cover the soil. Shredding the trees before dumping the remaining would increase the soil cover. The cover protects the soil from raindrop impact and reduces the velocity of runoff and wind.

Additionally, the trimmings of the grass hedges (see vegetative barriers) can be used as a mulch when it is not used as fodder.

A mulch should cover 70–75 per cent of the soil surface. A lesser covering will not adequately protect the soil, while a greater covering may delay plant emergence and suppress plant growth (Morgan, 2005). Natural succession is slower on newly exposed mineral soil, because of the lack of nutrients. Mulching with the right amount can therefore enhance natural regrowth of vegetation (Walker et al., 1996).

2. INTERVIEWS

1. 05-09-2017

Randall Johnson, Head of the department for Agriculture, Hygiene and Vector control.

What are the responsibilities and activities of the Agriculture Department?

Currently the responsibilities mainly are combating the rats and mosquitos that live on the island. Additionally the department sells some vegetable seeds for those interested in growing them in their own garden. The department itself owns a farm in Upper Hell's Gate, where they have a small irrigation system connected to a large cistern. The produced vegetables are sold at the weekly vegetable market at Breadline Plaza and occasionally directly to restaurants or shopkeepers.

What is the department's role in combatting erosion?

Concerning erosion, the department is planning on planting coconut and sea grape trees along the dirt road leading east from Fort Bay to Tent Bay. However, because of the coming hurricane season the planting will be postponed till November at the earliest.

2. 07-09-2017

Goat owners on The Level own approx. 20 goats for meat production.

Where do you sell your goat meat?

We distribute the meat on Saba and occasionally to Sint Maarten.

What is your opinion on the goat buyback program?

The buy-back project of the government was positive for the decrease of the goat population on the island. Without the buy-back project, many owners face difficulties finding a market for their meat. Providing such a market by the government could be an effective way of reducing the goat population.

3. 10-09-2017

Jessie, living at Little Rendezvous.

These fields once were cultivated, what is the reason they stopped doing that?

The agricultural fields once were abundant but most of them disappeared over time. Although the soils are very fertile, working conditions are harsh because of the high temperatures and steep slopes. Producing enough to sustain a living as a farmer is extremely difficult on Saba, if not impossible. It is therefore that most of the food is important from other Islands or from the American mainland.

4. 11-09-2017

James Johnson, trail guide/manager and working for SCF.

Where on the island do you see erosion problems?

He mentioned that on the island several erosion "hotspots" exist. One of them is located close to the old sulphur mine, more erosion takes place on the to the Bottom facing slopes of Bunker Hill and Paris Hill and on the many "guts" on the south side of the island.

What is the SCF doing in terms of erosion prevention?

The SCF is currently planting grasses to counteract this erosion in some places. Colleagues from Panama have good experiences with Guinea grass because it grows in thick mats. Thereby the grass prevents erosion caused by splash erosion and at the same time controls overgrow by corallita.

5. 12-09-2017

Jenny, employee of SCF and working at the trail shop.

Where does erosion damage hiking trails?

The North Coast trail and the Sandy Cruz trail, both on the north side of the island, are very prone to erosion. This side of the island is inhabited, which means that, besides the trail, no infrastructure can be damaged by erosion. On the other hand, the eroded soil will be transported all the way into the ocean directly.

Furthermore she mentioned a large landslide close to the sulphur mine, just behind a couple of houses in Hell's Gate. The house owners have been scared by that landslide so close to their houses and are afraid that it might move closer over time.

6. 12-09-2017

Tarzan, farmer on mountain road

How do you see the future of farming on Saba?

He sells the surpluses of his pineapples and citrus fruit to local people. He told about the agricultural past of the island, with many farmers and he brought up several ideas for future land-use. One of these ideas is providing extensive plant growing classes at the local school. By doing that he expects the youth to become more interested in farming or home garden growing. Another idea is the setup of larger agricultural projects together with the government and other locals. In that way, the island could become a lot more food self-sufficient and there would be less need for import from the United States or other countries.

How can that be combined with erosion prevention measures?

Why not use the plants to counteract soil erosion for growing fruits at the same time? All you would need would be a gardener/farmer to take care of the trees, to harvest the crops and to sell it. With the right crop you could produce at least enough for the whole island and probably be able to transport it to other places too.

7. 19-09-2017

Tim Muller, Island Secretary.

What is your vision on erosion and agriculture on Saba?

I am in favour of an expansion of agriculture on the island. This could lead to a lower dependency on import of food from other islands, especially in times of emergencies or when transportation is not possible because of bad weather conditions.

He brought up the idea of coffee trees, adding a new economic source to the island and assuring sustainable land management at the same time. The current farm owned by the government is to small to substantially feed the island.

8. 22-09-2017

Peruvian construction worker, collecting rocks at the Public Works dump location.

What was the situation of the dump site over the past years?

I am afraid to go all the way on the dump area because of debris slides. One section that was there some time ago, but is completely gone now. The water destabilizes the dump area, which is located in a steep gully. This regularly causes debris slides and the material eventually will flow into the ocean at Spring Bay. The soil, construction waste and organic waste is dumped, but not compacted. This means that the material is very loose and water can easily turn it into mud. When oversaturated, the material will slide into the gully.

9. 22-09-2017

Ryan Espersen, Director Sabarc – Saba Archaeological Center.

What are your views on past and future agriculture and erosion prevention on Saba?

An excellent research has been executed some time ago on possibilities for mushroom production. Unfortunately, due to a lack of stakeholder involvement and follow-up activities, this production never developed.

Additionally, coffee production could be a very interesting way of economizing erosion control. One crucial institution is missing on the island to make this successful, namely, a farmer's cooperative. A cooperative facilitates the selling of the coffee, bringing together multiple small farmers guarantees a more stable marketing. This would not only work with coffee, but with all kinds of agricultural products.

10. 23-09-2017

Will Johnson, former Governor and Saban politician

How is the agricultural sector on Saba developed and what are the reasons for the current lack of production?

An important aspect of the agricultural past of Saba was the independency of the predominantly white population on slavery. The population, mostly British pirates arrived after 1629, was to poor for the ownership of slaves. That means that the sugar and tobacco plantations on the island were solely worked on by Sabans. The abolition of slavery the 1st of July in 1863 therefore had no consequences for the agricultural sector on Saba.

Around 1665, after many decades of alternately Flemish, Spanish and British dominance only a few dozen to maybe 200 people remained on Saba. These British pirates were able to build large schooners and they used them for raids on the British and American Virgin islands. Due to British and French piracy combatting, the Sabans were forced to rely more on agriculture and fishery. The population was increasing and the soil was fertile enough to produce sufficient food. In the early 1900's potatoes were even exported to surrounding islands.

In 1922, oil refineries opened on Aruba and Curacao, which caused an important change on Saba too. The sea still had a strong attractive force for the originally pirate population and many left to work on the oil fleet of Esso. This caused a decrease of agricultural production on the island and an increase of the dependency on surrounding islands.

Another important factor that contributed to the decrease of the agricultural sector, was the construction of "The Road". In 1943 the road from the Bottom to Fort Bay was completed, and in 1958 the road was completed all the way to Flat Point. With the completion of this road, the period of subsistence agriculture on Saba started to end. Being able to move between towns and to access the harbour by car provided opportunities to economize the fishery sector and to take government jobs in the Bottom.

Little Rendezvous (cultivated by farmers from St. John's), Big Rendezvous (cultivated by farmers from Windwardside) and Sandy Cruz (cultivated by farmers from Hell's Gate) lost their economic value and nowadays there are only remnants of the agricultural period left.

What has been done by the government to change this?

The government and local newspapers have made efforts in the past to increase the interest for farming on Saba. The area next to the museum in Windwardside was designated for agriculture. Additionally, the Agriculture Center was constructed in the English Quarter to provide islanders with advice and materials for farming. In the past, growing competitions have been set up for the same purpose. Despite these efforts, only a handful of people are growing significant amount of crops. Since 2007 Cuban agricultural experts have assisted with the development of the Organoponics Garden, one of the largest and most productive agricultural facilities on Saba. Because of the USA embargo after the Soviet Union period, urban agriculture in Cuba is very large and well-developed. The Garden on Saba has the purpose of experimenting with different crops and demonstrating the possibilities of organic home garden production for Saba's inhabitants.

Have there been soil conservation measures in the past? Were they effective? If not, why is that the case? If yes, can they be improved?

During the agricultural heyday of Saba in the early 1900's, erosion was controlled by placing chopped tree logs in horizontal position behind the stumps. This was effective as long as the logs do not rot, but this method is not used anymore.

Are there any soil conservation measures currently implemented?

In Hell's Gate, a government garden has been constructed and this is cultivated by the Agriculture Department. Furthermore there have been ideas to plant Mahogany trees on slopes prone to erosion, since goats do not eat the young trees.

11. 27-09-2017

Desiree Soares, Tourist bureau Windwardside.

What are the effects of erosion on Saba's tourism?

The two main touristic attractions, namely dive sites and hiking trails, are both seriously affected by erosion. At the moment, tourists are scarce on the island because normal transportation is still not possible due to hurricane damage. However, in December more tourists are expected to arrive and damaged hiking trails and/or dive sites will decrease the island's appeal.

12. 04-10-2017

Kai Wulf - Saba Marine park manager

Where does SCF experience problems with erosion and what is the cause?

At different places hiking trails are damaged by erosion caused by natural processes and also caused by human actions. One example of that is Tent Bay where sand was placed after emptying the harbour. It was known that it formed a risk for the reef next to it, a replacement request was written by Jennifer Rahn, but the sand has never been moved. During the past hurricane large parts of it disappeared into the sea.

At Mary's point, the erosion causes damage to the hiking trail and the historical sites next to it. SabArc has interest in restoring that place. Parts of the North Coast trail have been rebuild several times because of erosion, but this happened at very remote locations which are hard to reach with vehicles and machinery.

Eventually all the eroded material ends up in the sea and this has an effect on the coral reefs. It is not only the dive sites, but biodiversity around the entire island is affected. The dive sites are chosen for several reasons, such as accessibility, distance etc. the state of the reef is just one aspect. The habitat map of the Marine Park shows that in more detail.

What has the SCF done in the past to prevent this?

We have done several tree planting projects around the island. Additionally we try to raise awareness of the islanders, kids in particular. Not everyone sees that erosion is a serious issue and that is the first step of solving the problem.

Does the SCF have future plans regarding erosion prevention?

We want to continue with the tree planting but we need more manpower to execute that, furthermore we would like to see better policy and legislation on land management. A good spatial planning for the island would support that, together with building codes that are strictly enforced. The goat buy-back program was effective, yet only for the time being. That means that such program need to be enforced again, but than for a sustained amount of time. The population needs to be maintained at a sustainable level. Additionally, good education on nature and erosion would help to raise the awareness of the people and their willingness to support different projects. In the end everyone on the island is depending on the beautiful nature and the tourists that it attracts.

What would the SCF need for these plans?

Manpower is the most difficult aspect to assure right now. The Saba bank is managed by only 1 person right now, the Marine Park by 2 and the terrestrial part only by James Johnson. He is assisted by 6 trail cleaners that are paid by the government and Stephanie runs the trail shop. Finding new people that want to spend their days outside doing physical work is very hard.

Financing is another difficult thing, although fairly good at the moment compared to other islands. This is the case because of the Nature Ordinance which makes sure that every tourist pays a fee that goes directly to the nature management and not trough the government first. These fees are very small and we do not always receive the right amounts, also the last increase was in 1991 while prices have risen in the meantime. On Bonaire they have a system of arrival fees, which is easier to check and control.

Who owns the land where the trails are on?

The trails are protected public property, but not owned by anyone. At all times it is not allowed to deny access to the trails and building on them is prohibited. Most of the trails are very old and part of the Saban culture, since they have been the only possibility for transport for a long time. At the moment there is a government policy that building is not allowed above 550 meters, but this is not enforced by any legislation. Spatial planning for the island is on the government's agenda, but not yet made. Since every little piece of land is owned by someone, land rights and ownership is very difficult to map let alone to change.

During the development of the zoning map of the Marine Park, this was also an issue. To avoid any problems, the zoning as it is today was done to avoid problems.

What are the SCF's responsibilities regarding the trail and dive site management?

The management is delegated from the government to the SCF, because they do not have the necessary resources, materials and manpower. They also do not have enough financial possibilities, so right now the SCF is funded by nature projects and via a trust fund together with the Dutch Caribbean Nature Alliance.

13. 05-10-2017

Menno van der Velde - Senior policy advisor

What is the land management policy or planning regarding erosion on Saba?

First you have to know that almost all the land on Saba is privately owned and for only 20% of the land area on Saba this ownership is clear. That means that the ownership of the remaining 80% of the land area is not officially registered and over many generations plots are often divided in very small parts. This is the case because Saba did not have a notary for the official registration of landownership and for approval of land transfers. The latter, therefore, mainly took place based on written and stamped agreements.

This is situation is very different to the situation in the Netherlands and also to the other Dutch Caribbean islands, where landownership is better registered. It is therefore that spatial planning on Saba is not implemented, it will simply not improve the situation since the government owns almost no land. It also means that any kind of project has to deal with scattered and unclear land ownership, as is the case for erosion prevention. The government, or other parties, can propose a certain project at any location and from that moment landowners can report themselves. When official landownership registration is lacking, claimers will get the change to arrange this via court. Government will assist where possible with the search for the heirs to complete the family tree and thereby tries to find the current landowners. At the moment, there are several examples of successful landownership transfers for both private and government projects such as the solar power fields at Flat Point, a church's graveyard, erosion prevention at Tent Bay and a vegetable garden in Hell's Gate.

Mediation between project proposers and possible landowners has been, and will be, the way to achieve change in land management on Saba.

Who owns the hiking trails and how can man-made erosion be prevented on these locations?

The land where the trails are located on is privately owned and since a very long time these trails have right of way. That means that concerned landowners are not allowed to block or damage these trails, this includes not building on top of them. When violation of this right of way is noticed, the concerned landowner should be reported to the police and thereupon they will undertake the correct judicial action.

What is the situation regarding the dumpsite at Spring Bay gut?

This gut is privately owned and permission is given to the islanders for the dumping of organic material and construction waste. It is known that with heavy rainfall this material erodes away and flows down in the direction of Spring Bay. The solution for this would be a concrete drain placed under the road to transfer access runoff from upslope into the Spring Bay gut, bypassing the dumpsite. Unfortunately, this would be a very costly construction and the government cannot afford that at the moment.

14. 05-10-2017

Reed, sheep and goat owner at St. John's and Little Rendezvous

What livestock do you have?

He lets his sheep graze at Little Rendezvous and visits them twice a day. His goats are roaming free in between St. John's and The Level.

What is your view on the goat buyback program?

During this program I had a very active participation. However, problems arose when I was accused of shooting someone else's goats. In the end it turned out that this was not the case. This could be avoided in the future by more active participation of local law enforcement in the goat-buy-back program.

15. 09-10-2017

Lloyd, goat and sheep owner at the Level

What livestock do you have?

I own a maximum of 25 goats and 20 sheep, knowing that increasing this amount would damage my properties because of overgrazing. Based on 45 years of animal husbandry experience I know the maximum sustainable amount of goats on my and my brother in laws fields. I purchase new bocks from Puerto Rico to make sure the herd stays healthy and to avoid inbreeding. This costs a lot of money, but in the end it pays off. My goats are very large, healthy and have a good amount of flesh on the bone.

What is your view on the goat buyback program?

Since all my goats live on my own land and do not roam freely I did not join this program. As told before, I know my maximum number of goats.

Do you ever face erosion problems on your land?

My fields are very well maintained, they are green and the grass is tall. I start with planting elephant and guinea grass and that I wait for it to be tall before he put his goats on. Especially in times of a drought (February 2017 was the most recent one) goats tend to eat all the vegetation that is left, making the land very prone to erosion. With this practices I do not have any erosion problems on my land

16. 09-10-2017

Anna Keene, manager of the Organoponics Garden (aquiverattheriver@yahoo.com)

What is your view on the erosion issue on Saba?

One thing is the enormous decrease in agricultural production since the 60's when canned vegetables arrived in the supermarkets on the island. Farming has always been very difficult on Saba. Although the soils are relatively good and the climate is favourable, the geomorphology makes it really hard to farm on large scale and with machinery.

And what has been changing the parts where agriculture never started?

This is a combination of climatic influences together with the free-roaming goats. During 2014 and 2015 and 11 month drought took place and last year a drought lasted 6 weeks. During these times vegetation has a really hard time staying alive and goats exacerbate this be removing all young sprouts that are left. Eventually, the goats have to move to higher ground looking for food. These droughts are expected to increase in numbers and strength because of climate change. It is already noticeable that the supposed to be wet and dry seasons are not so distinguishable anymore and that it gets more unpredictable.

What could be interesting plants for erosion prevention that you know off?

Wedelia could be a good one, since the plant grows roots wherever it touches the ground, as is the case for Water weed. Nutgrass could be useful as well, this grass' roots grow horizontally and popup to grow leaves. This leads to an underground network of connected roots, which holds the soil really well. As far as I know, goats will not eat it. However, attention needs to be paid to where you plant it, because you do not want to have it growing in your garden.

What else has been done on the island to prevent erosion?

Except for this garden and the one in hell's gate by the government and a couple of other home-garden growers, not so much has been done to prevent erosion. After a lethal accident on the Fort Bay road, a fence was constructed to stop rocks from falling on the road. This is effective, but not sustainable since it will fill up with rocks and will need to be rebuild soon. Government legislations and policies on land management have proven to be very difficult to enforce on this island, so in the end awareness raising is key.

What can the Organoponics Garden do regarding ecological awareness raising?

We work together with the schools to have fieldtrips visiting the garden, providing hands-one education on growing vegetables and fruits. One particular project was together with 4th grade and in the end all the kids wanted to take home sweet potatoes to start growing themselves. We did the same with beans. This education and awareness raising is a very long-term investment, but crucial for achieving sustainable land management. The same counts for geography class in high school, setting up erosion experiments with the students, for example with a tilting table filled with sediment, will increase their knowledge and awareness.

17. 10-10-2017

Tom van't Hof, one of the founders and former board member of the SCF

How did the responsibility of the hiking trails and the mooring lines end up by the SCF?

He was asked to set up the Saba Conservation Foundation together with the Saba Marine Park to the STINAPA example. Traditionally, in the Netherlands Antilles the nature management was done by NGO's since local governments did not have the interest and resources to do that. That means that the development of independent nature conservation foundations very much was supported by the government. The SCF started with the management of the Marine Park, but her goals were broader. The management agreement was given by the executive council.

And the management of the trails?

The management of the trails came later, the maintenance was carried out by the government that hired trail cleaners. The SCF saw potential in the trails for tourism, provided that the maintenance was done properly and was combined with good signs, guiding etc. The management of these historical trails was handed over under two conditions. First, the maintained finances would go to the SCF straight and second, James Johnson would go work for the SCF as trail manager.

The new management, combined with signs, a trailplan and adjustments improved the trails dramatically. Thereby increasing its value for tourism in Saba, from that moment onwards, diving was not the only eco-tourism attraction. Management of trails has to be done in consultancy with the relevant landowner, since the trails have right of way but are located on private land.

What is your view on the erosion problem on Saba?

Sedimentation on the reefs has two sides, on one hand it is necessary for the growth and life of coral, but on the other hand too much can damage the coral. This subtle balance in nature is difficult to sustain when mankind is interfering. On a steep volcanic island like Saba, erosion is a given and has been present since it birth. Prevention is therefore only needed in places where natural erosion has been enhanced by human actions.

What is the role of SCF in handling this problem?

Awareness raising has been one of SCF's goals from the beginning, but increased a lot since the employment of people specialist in working on that. A large variety of projects, including school and afterschool activities, have been set up. The historical knowledge and awareness on land management was very good and is still there in the minds of some old Sabans. Awareness raising for kids is very important for their future willingness to cooperate in nature conservation projects.

Have you seen results of this awareness raising in people's willingness to cooperate?

Awareness raising is always a very long-term process and results are difficult to see or analyse. But for the development of the national park landowners were very cooperative, but they wanted to keep the option on using the land for agriculture in the future. When taxes on land would be implemented, a tax reduction could be developed for joining nature parks.

18. 10-10-2017

Ryan Espersen, Director of Saba Archaeological Center

Do you see erosion as a threat to archaeological sites on Saba and where has it caused damage?

To a certain extent I do. On one hand, erosion and especially sediment layers preserve archaeological sites by covering them. This is the reason that the site at the electricity plant stayed untouched, the digging was not done deep enough to damage the covered remaining. On the other hand, erosion damages some of the other sites. At Mary's point the cliffs are just falling apart and creeping in towards the ruins. One of the historical cisterns is hanging partly over the edge of the cliff. At Cove bay erosion has filled up indigo vats that we cleared before. This means that we have to clear them again, a very labour intensive job. At the right side of the Ladder part of a ridge has come down into the gut. This happened in the early colonial period, we can still find artefacts but the site is practically gone. In the middle of the pirate cliffs, an entrance to an early sulphur mine is visible but impossible to reach since everything around it has come down. The entrance of the actual sulphur mine has been partly filled up a couple of times.

What would you like to do, or see done, to prevent this in the future?

Seeing the amount of Styrofoam pieces in the Cove bay vats, the erosion must have been recent. The vats are around a meter in depth and there even was another half meter of sediment on top of the hill side part of the vats. I hope to be able to get a machine excavator to create a pathway to the vats and to dig them out completely. When that is happening, I will create a retaining wall on to the hill side of the path to stop erosion. This could either be a concrete wall, or a more aesthetic drystone rock wall.

What would you need to implement these preventive measures?

Since SabArC is a very small organisation and I am the only person working for it at the moment, it just lacks resources for such operations. The center has knowledge on the different locations, but not the financial resources or the necessary manpower.

19. 12-10-2017

Randall Johnson, Head of the department for Agriculture, Hygiene and Vector control.

What is your opinion on the goats on Saba?

I just had a talk with goat owners, where I asked how many they had shot since the hurricanes. Originally, goats are a backup food source during difficult times. You would expect that 2 category 5 hurricanes are about as worse as it gets, but none of the goat owners had slaughtered and sold more goats than they normally would. This illustrates the unfounded argument, often used by goat owners, that goats are needed to survive times without food deliveries.

20. 18-10-2017

Goat hunter on Dancing place trail facing Gile's Quarter

Where do you hunt goats?

I hunt my own goats on the ridges and in-between the guts from Booby Hill toward the Gile's Quarter trail.

What is the population size at the moment?

The population is too large at the moment. Nature does not have time to grow back since goats tend to eat the young sprouts and trees. By walking up and down the slopes they move rocks and cause erosion.

What is your view on the goat buyback program?

The goat-buy-back program was not effective enough, because it removed not enough goats and they breed very fast.

How can this be improved in the future?

I would suggest stricter rules on the ownership of goats, people should take care of their herds, manage their numbers and slaughter them at the right moment. This is not only better for the environment, but also for the meat, since healthier goats grow bigger.

21. 22-10-2017

Conversations during the map-making session.

- Saba should start with a Goat-tagging policy. The sustainable maximum amount of goats per area has been discussed with government officials before. I think that a low-cost permit to hold goats (like dog-tax) should be introduced. Every goat owners than gets his tags (different colour for each owner) and all the un-tagged goats will be shot and sold without compensation for the owners.
- Punishing bad behaviour (e.g. causing erosion) does not seem to work on Saba, legislations are not always enforced and the police does not want to be involved in the goat issue. It might be time for a more positive way of trying to solve this. Rewarding good behaviour (e.g. fencing goats) might work more effective on this island where people often do not accept orders from above.
- St. Kitts has a veterinary school and they might be willing to help with castrating goats and to control the breeding.
- The walls on either side of the roads are solid and that leads to rainwater flowing over the road and that funnels into one area (with erosion as result). Rebuilding the road walls with a permeable wall will divert the water from the road and decrease erosion rates.
- The gut parallel to Fort Bay road has been built to drain the water from the Bottom to the harbour, but all the dirt is just taken away because of the water. They should divert the water over the road, where it cannot erode the sides of the gut. During the construction of the gut, the material was just dumped there and has not been covered by vegetation.

22. 23-10-2017

Stacey Mac Donald, previous researcher on Saba's view on nature conservation

I read your article in BioNews by chance and was wondering whether you have information on the awareness of the local community towards erosion because of your research. I understand that erosion might be a bit to specific, but any insights in people's awareness regarding nature conservation on Saba might be of help.

Thanks for getting in touch with me. Like you mentioned, I have not done any specific research on Saba concerning the perceptions towards erosion. However, I have interviewed several people on their views about nature conservation. What I understand from Saba is that people are in general quite aware of the importance to conserve their natural environment. They know it is THE selling point of the island, and although people admit there is still some littering that takes place (which they often blame on people who originally not from Saba but from elsewhere in the Caribbean), they are in general very supportive of all conservation, and that value seeps down into the rest of the community. Most people who live on Saba, I feel, also have a bond with nature in the sense that they are (and in the past even more so) very depended on their natural resources (e.g. rainwater).

That being said, it's often not the 'real Sabans' themselves that conserve the environment, but the most active groups usually consist out of volunteers and the expats on the islands. And, just because people value their environment doesn't necessarily mean they conserve it in the best manner. This could be because of a lack of knowledge (simply not knowing what is causing the damage), at times it can also be more political (politicians fear to intervene because they fear the loss of votes). I believe that on Saba, it mostly has to do with a lack of knowing and perhaps thinking the government is the main organisation or institution that needs to take care of the environment.

So, in short, I believe people on Saba in general are aware of the importance of conserving their natural environment (this is based in a sense of pride), but do not necessarily know what they should be doing/how they should be protecting their environment. Educational campaigns for and information sessions with the local community often go a long way, especially when supported by the government. I would always advice organizing public information sessions that allow for debate on the issue and involve the ideas or knowledge of the community. And then guiding them through the issue, trying to explain it in such a way that it hits close to home (almost directly effects the community or individual in a negative manner if you do nothing, and in a positive manner if you do something about it).

23. 27-10-2017

Marc Dobbs, History and Geography teacher at the Saba Comprehensive School. After the school experiment and presentation I gave, he asked me to keep him informed on future tree planting projects. Especially for the geography children this could be an interesting activity. This too might be interesting for other classes. Children can play a large role in planting the trees and harvesting certain fruits and nuts.

24. 01-11-2017 Jonathan Johnson, Island Governor of Saba.

Where do you have erosion problems on the island?

There you can see two erosion spots on Paris Hill and Bunker Hill and those are not the only ones. The goats are causing many of the erosion problems and the Buy-back program only worked for the time being and to many goats where left.

How can this be improved in the future?

The government could facilitate and support a better goat management, by bringing in healthy goats and putting up fences. Better goat management would be very beneficial for the few goat owners that still have the free roaming goats. Right now the goats are small and they do not have very much and very tasty meat. More sustainable management would help the land and the goat owners.

25. 01-11-2017

Russell Thielman, head of the Public Works & Sanitation Department

Do you see erosion as a threat to infrastructure on the island?

Yes, definitely. We take erosion very serious and did a survey in 2004 to identify erosion problems with the roads. Erosion is the reason that we have safety walls on the lower sides of the road and retaining walls on the upper sides of the road.

Where does erosion cause damage?

Along the Gile's Quarter road and in the Spring Bay gut erosion is very problematic. The same goes for the Hell's Gate cliffs. Next to the Med School dorms erosion has taken away the side under Crispeen trail and overflows the yellow-clay soil next to the Med School. This could be prevented by directing the water higher up into the gut. The Wells Bay road faces some erosion problems too, on the hillside we are planning on raising the retaining walls. The Fort Bay road has a tunnel under the S-curve, but this is regularly blocked by rocks and sand. With heavy equipment we could get rid of this material. Most problems though, are occurring at the landfill in the harbour. Water and sediment comes all the way down from St. John's through that gut.

What have you done to prevent this in the past?

Building road walls is important, additionally we have built different staged walls to prevent landslides. One example is next to the Spring Bay gut landfill. Together with the Agriculture Department we have done some tree planting projects along the Gile's Quarter road, we have planted a lot of Flamboyant trees and they did very well. Some time ago we have planted Mahogany seedlings in the Hell's Gate and spring Bay guts, but only a few survived because the goats started eating them.

What would you like to do or see done to prevent this in the future?

I am not fond of the landfills, but we need to get rid of our excess material somewhere. The landfill in the Spring Bay gut is private property, which makes it difficult to change things, but I want to block it with large rocks, since rock building is the original Saban style. Together with that I would like to plant different flowering trees on the sides of the landfill. Another thing that would help prevent erosion of finer sediments, is sifting the material and re-using the sand and clay for people's gardens etc. That will reduce the amount of fine material that will end up in Spring Bay and harm marine life.

For the Fort Bay road gut and the Fort Bay landfill I propose to build rock dams in the guts, to slow down the water and the catch sediments before they reach lower land or the ocean. We might be able to use excess car tyres to build dams as well, but I am not sure yet whether the tyres will cause environmental problems.

The fence along Fort Bay road has very high yearly maintenance costs (100.000-150.000) because the net breaks due to large rocks. Preventing erosion upslope would be very helpful, we could do more tree planting to accomplish that. On the upper side of Gile's Quarter road I am thinking of planting a sea grape hedgerow, which is very good to prevent erosion and looks beautiful, we always have to take that into account as well.

Public Works has a good relationship with the Agriculture Department, they provide the seedlings or slips and we can assist with planting and management.

What resources do you already have and what would you need for this?

Public Works has some large machineries and equipment, including contractors, but we need more financial resources. When we would do more of these projects we could use a Bucket truck and a truck with a lift platform for heavy equipment and the landfill need at least a 10 ton machine excavator. The Agriculture Department would need to buy the trees for the planting projects, but we have most of the equipment and manpower available.

Did you ever encounter difficulties with property rights during these projects?

Not really, people are very willing to cooperate when they see that it is necessary or important. For example the road had to be widened in some places and that was no problem. The same for planting trees, that is only improving the land and I do not expect problems with that.

Additionally I think on doing a drone video project to film different erosion sites from above, to show the people and the government the urgency of these projects.

26. 01-11-2017

Terry Cunningham, gardener on Booby Hill.

Where do you face erosion problems?

Damage is caused by water flowing from the Level over my garden. This water ends up on the road and flows, together with the water from the level road, on the drive lane of a house. Oddly enough, this is not exactly the lowest point of the road, because that is at the gut leading to the Banana Gut. Water from the Level ends up in one location next to the Organoponics farm and flows down to Booby Hill.

How can this be improved in the future?

This accumulation of water in one place leads to erosion, while retaining this water higher up or diverting the water over more locations would reduce this erosion. By the construction of infrastructure and buildings, the flow direction of the water should be taken into account. Better compliance with building codes could assure this reduction in erosion.

27. 02-11-2017

Randall Johnson, Head of the department for Agriculture, Hygiene and Vector control.

What resources would your department need for the implementation of erosion prevention?

Knowledge on the right tree types and grass species might be of help. Right now the department uses oleander and sea grape trees for prevention, but I expect that there are more types that could be useful but are still unknown to me. Furthermore, financing would help to speed up things. At the moment, tree clippings are used to grow new trees which takes a long time. Often, the soils are poor and the tree would not survive without compost and/or manure. Because of the goat population, every planted tree has to be fenced. The current budget for the Apartment does not allow for this costly planting at large scale.

28. 04-11-2017

Andrew, experienced diver with 1500 dives around Saba

Have you noticed damage due to sedimentation on the coral reefs?

Especially after Maria you could see a fine layer of sand and silt as a blanket over the coral. This was most visible on Tent reef, because it is very close to shore. And right above Tent bay steep slopes are located.

29. 10-11-2017

Vegetable farmer on Saint Kitts, planting cucumber seedlings

Do you experience soil erosion on this island?

Yes, because my fields are located on a slope the soil is very prone to erosion. Especially with heavy rainfall in the mountains, water flows down over my fields. You can see the gullies it has formed lately.

What are you doing in terms of erosion prevention?

On the sides of my fields I have built small stone bunds to direct the water over the dirt road away from my land. This prevents the water from flowing on to my land and thereby does not erode the soil.

Are you able to market all of your products on the island?

Yes, I produce cucumbers, watermelons, different kinds of peppers and sweet potatoes. All of the products are sold to the local supermarkets. We could even sell more if we could produce it, since a lot of food is still imported from the States.

30. 10-11-2017

Willem van Hees - ProCarib, developer of the Nature Policy Plan Caribbean Netherlands 2018-2022

De afgelopen 2 weken ben ik vooral bezig geweest met een zogenaamde stakeholder analyse, waaruit vooral blijkt dat de toeristische sector last ondervindt van beschadigde wandelpaden en koraalriffen. Uiteindelijk is bijna het hele eiland afhankelijk van het inkomen uit die sector.

Het is mij ondertussen duidelijk geworden dat de meeste kennis m.b.t. erosiepreventie voor handen is, maar de uitvoering lastig blijkt te zijn. Naar mijn idee zit dat in twee aspecten, de eerste is het private landbezit (vaak ook onbekend wie dat zijn) en de tweede de handhaving van de regelgeving rondom het houden van geiten, het dumpen van afval etc. Je hebt gelijk, dat de 'wat' vraag dikwijls niet zo moeilijk is. De 'hoe' vraag is vaak des te lastiger. En daarin is elk eiland echt heel erg verschillend. Dus als mijn ervaring vooral op Bonaire ligt, betekent dat niet zomaar, dat ik een nuttig oordeel over situaties op Statia of Saba kan hebben. Zo heeft Saba inderdaad veel eigendom en Bonaire omgekeerd veel erfpacht ne huurterreinen. En zo heeft Saba steile hellingen terwijl Bonaire juist ook veel vlak heeft op zeeniveau.

Uitvoering begint met draagvlak. Als er geen wil is, dan kun je duwen wat je wil maar blijft t lastig en tijdslopend. Onbekend eigendom kan een excuus zijn, maar kan – bij wil – niet blokkerend zijn. De belang van het terugdringen van erosie moet voor zowel gemeenschap als de individuele eigenaar duidelijk zijn. Wat worden we er beter van. Koraal is dan niet altijd een houdbaar argument. Dat raakt toerisme, wie is daar vanwege het koraal op Saba van afhankelijk, zijn dat echte 'born' Sabanen, etc. Ofwel is er een belang dat dichter bij de 'oude' Sabanen ligt. Is er uitruil van belang nodig, omdat iemand dwars zit omdat ie in een andere situatie dwars gezeten werd. Anders gezegd, het is zoveel minder anoniem dan in ENL, dat je echt tot op dat individuele niveau de benefits en obstakels helde moet hebben. Dan ligt er mogelijk een kans en doorbraak.

Een vergelijkbare situatie is de instelling van Mt Scenery, hoger dan 450m?, als natuurpark. Ook daar was eigendom het issue. Ik kan de laatste stand van zaken niet precies, maar er werd wel een opening gevonden, oa met de hoogtebegrenzing van bouwvergunningen.

Verwacht niet dat het beleidsplan op niveau van projecten erg concreet wordt. Dat is tactisch en operationeel. Beleid is abstracter, meer hoofdlijn op strategisch niveau, te vertalen daarna in operationele maatregelen en tactische keuzen.

31. 02-12-2017 Kai Wulf – Saba Marine park manager

With Randall and Russell I discussed a plan to prevent erosion by planting different types of vegetation. Randall can be in charge of arranging the plants and Public works has more manpower and equipment. Additionally, many inhabitants of Saba are interested in helping with planting, which was one of the results of my questionnaires. I believe this is an opportunity for the SCF, for example to host a variety of "tree planting days". That can be done by announcing a Facebook event, just like you did with the trail clearings. As I said, I think the Agriculture Department and Public Works should be responsible for the plants, the financing and the equipment, but I believe that the SCF as an NGO is more likely to be able to actively involve the community.

Yes, I like the idea and think that SCF would be able to bring together enough people to make it work. We do have the equipment as well, but lack the plants and expertise on planting.

QUESTIONNAIRE PART 1 - BEFORE PRESENTATION

Please tick the box that applies to you	Yes	° N
Is your stay on Saba permanent?		
Do you own land on Saba?		

What is your age? <18 18-30 30-50 >50

Please re-order the following environmental problems on Saba (1 being most severe and 6 being least severe)						
Degradation of coral reefs	1					
Droughts	2					
Hurricanes or tropical storms	3					
Invasive species	4					
Overgrazing by goats	5					
Soil erosion	6					

	strongly agree	agree	uncertain/ not applicable	disagree	strongly disagree
Soil erosion is a threat to Saba's infrastructure					
Soil erosion is a threat to the nature on Saba					
Soil erosion is a threat to the marine park around Saba					
Soil erosion is a threat to Saba's tourism sector					
Soil erosion is a threat to agricultural production on Saba					
Measures are needed to reduce or prevent soil erosion					
More money needs to be invested in these measures					

How would you grade your willingness to cooperate with erosion prevention projects? (Please give a number from 1 (not at all willing) to 10 (very much willing)

QUESTIONNAIRE PART 2 – AFTER PRESENTATION

Please re-order the following environmental problems on Saba (1 being most severe and 6 being least severe)						
Degradation of coral reefs	1					
Droughts	2					
Hurricanes or tropical storms	3					
Invasive species	4					
Overgrazing by goats	5					
Soil erosion	6					

	strongly agree	agree	uncertain/ not applicable	disagree	strongly disagree
Soil erosion is a threat to Saba's infrastructure					
Soil erosion is a threat to the nature on Saba					
Soil erosion is a threat to the marine park around Saba					
Soil erosion is a threat to Saba's tourism sector					
Soil erosion is a threat to agricultural production on Saba					
Measures are needed to reduce or prevent soil erosion					
More money needs to be invested in these measures					

How would you grade your willingness to cooperate with erosion prevention projects? (Please give a number from 1 (not at all willing) to 10 (very much willing)

What would you be willing to contribute to possible erosion prevention projects?

(e.g. helping with tree planting, donating money, making your land available for planting, managing sustainable goat populations, etc.)