Nexus interventions for small tropical islands: case study Bonaire

Introduction

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Following global trends in population growth, urbanization and rising living standards, the global demand for water, food and energy is rapidly increasing. Meeting this surge of demand poses heavy pressures on existing water, food and energy systems. Typically these have already been constrained due to the competing needs for limited resources in many parts of the world and growing climate change effects. These challenges are even more pronounced for Small Island Developing States (SIDS), due their small size, high population density, remoteness from centres of production, and vulnerability to environmental and exogenous economic influences. Nevertheless, achieving access to affordable, reliable and sustainable water, food and energy within the island boundaries is often possible. This requires a holistic "Nexus approach" that considers the inter-connections between water, food, and energy sectors in relation to the ecosystems on which these sectors depend. In this context it is vital to seek interdisciplinary solutions to scarcity of resources that allow mutually beneficial responses and synergies between sectors that promote efficiency while at the same time they reduce ecological degradation. Using the Caribbean island of Bonaire as a case study, we explore how this "NEXUS approach" can aid resource and ecosystem security in SIDS.

AN INTERLINKED WORLD

Water, food, and energy security are fundamental to modern society. Global trends in population growth, urbanization and rising living standards, are intensifying the demand for these resources which is estimated to increase by more than 50% by 2050, in comparison to 2015 levels (Ferroukhi et al., 2015). Meeting this surge of resource demand poses a huge pressure on existing water, food and energy systems, and the ecosystem on which these systems depend. Adding to this is the growing threat of climate change, which will have huge impacts on ecosystem functioning and related resource availability. Given this tremendous world-wide challenge, it is increasingly clear that in an interlinked world, there is no place for conventional planning and decision making that focusses on single sector approaches. After all, increased pressure on one of the resource sectors often has negative consequences for one or more of the other sectors, due to the presence of trade-offs and feedback loops. The production of agro-fuels, for example, requires water and occupies land that could be used to grow food or to support the natural environment and ecosystem services. Large-scale dependence on groundwater pumping for irrigation often leads to increased pumping in case of drought, and subsequent increased electricity demand. When this coincides with water shortages for cooling power plants and hydropower generation, this can interfere with power production and lead to power outages potentially affecting the whole population. Thus, increasing evidence suggests that international goals such as the ambitious Sustainable Development Goals (SDGs) and the Paris climate agreement can only be achieved with an integrated, multidisciplinary (beta- and gamma) and interdisciplinary NEXUS approach.

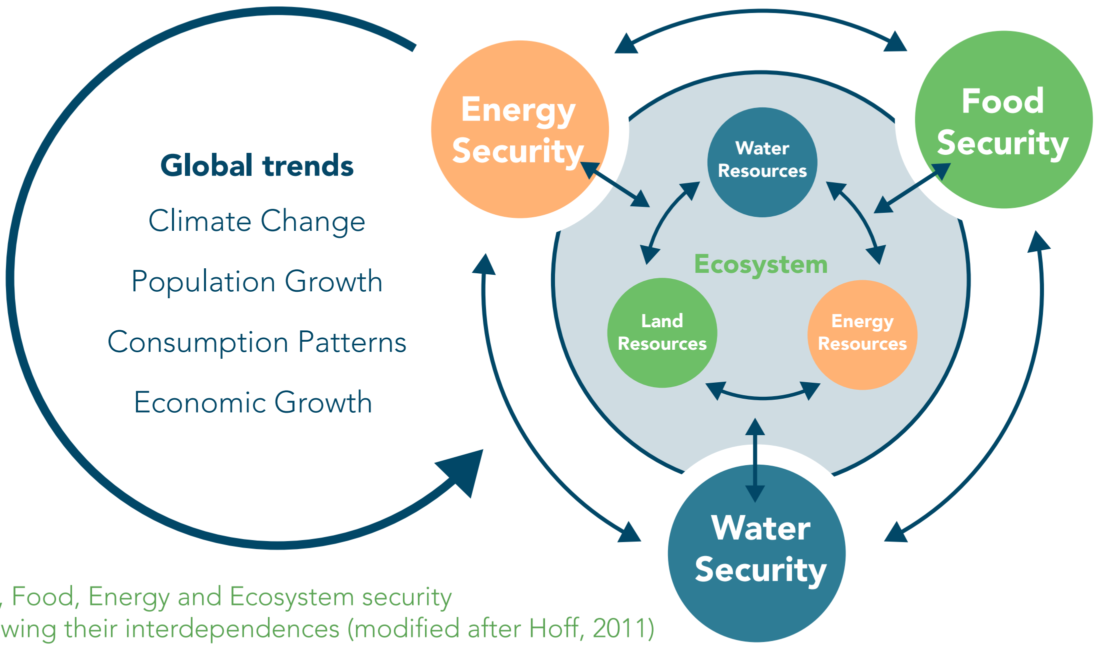

Figure 1.
The Water, Food, Energy and Ecosystem security Nexus showing their interdependences (modified after Hoff, 2011)

In recent years, the **Water-Food-Energy-Ecosystem (WFEE)** Nexus has emerged as a powerful concept to capture these interdependencies between ecosystems and the water, food, and energy sectors (see Fig. 1), and is now a key tool for policy-making. This Nexus approach helps to define trade-offs between resource sectors and the environment and helps build synergies across these sectors and the environment to increase resource use efficiency. In comparison to existing independent sectoral approaches to the management of water, food, energy and ecosystems, this Nexus approach thus helps to reduce costs and increase benefits for both society and environment. However, there is concern that the Nexus approach represents primarily a framing of issues and a call for action with limited practical value (Leck et al 2015).

Small Islands Developing States: the ideal candidate for the Nexus approach

Small Island Developing States (SIDS) comprise 52 countries and territories, that are home to more than 50 million people, 43 of them located in the Caribbean and the Pacific regions (Boto & Biasca 2012). The natural, economic and social systems of SIDS are considered highly vulnerable, due to the intrinsic characteristics of SIDS, including: small size; relatively high population density, remoteness; vulnerability to external (demand and supply-side) effects; narrow resource base; and exposure to global environmental challenges such as sea level rise (Briguglio, 1995). With their fragile ecosystems, SIDS are also highly vulnerable to domestic pollution factors (Boto & Biasca 2012).

These challenges were highlighted in the 1994 Barbados Programme of Action (BPOA) and the Mauritius Strategy of Implementation (MSI) of 2005, both of which stated that the difficulties SIDS face in the pursuit of sustainable development are particularly severe.

SIDS are thus a potential model for the future, facing now what must become the long-term preoccupation of the whole world as resource degradation approaches the limits of the planet. Given the tremendous challenges SIDS face, applying the nexus approach to SIDS may be particularly beneficial in embedding and achieving sustainability. Moreover, the reduced complexity typical for small and isolated tropical islands states, offers an unique opportunity to identify nexus challenges, and possible solutions that can be effectively implemented and monitored. As such, implementation of the nexus approach on SIDS, can contribute to the urgently needed proof of the practical value of the Nexus approach.

Typical negative feedback loops for SIDS

The challenges that SIDS face are varied, but all conspire to constrain their development processes. SIDS typically do not have a wide base of resources available to them, and thus do not benefit from cost advantages that this could potentially generate. Coupled with small domestic markets, they experience difficulties in profiting from globalisation and trade liberalisation and are reliant on external and remote markets with limited opportunities for the local private sectors. The costs of the provision of energy, infrastructure, transport and communication are also often high, and along with typically high population densities, create increased pressure on these already limited markets. (UNEP 2014, Dodds & Bartram 2016)

In addition, SIDS typically have a heavy reliance on unsustainable tourism, which enhances coastal deterioration through increased coastal erosion, pollution and disturbance, eventually leading to loss of coastal ecosystem services (Fig. 2). As a result, SIDS gradually become less attractive as a tourist destination. This will tend to lower the number of visiting tourists, and reduce the financial income of tourist operators, which again drives unsustainable tourism practices.

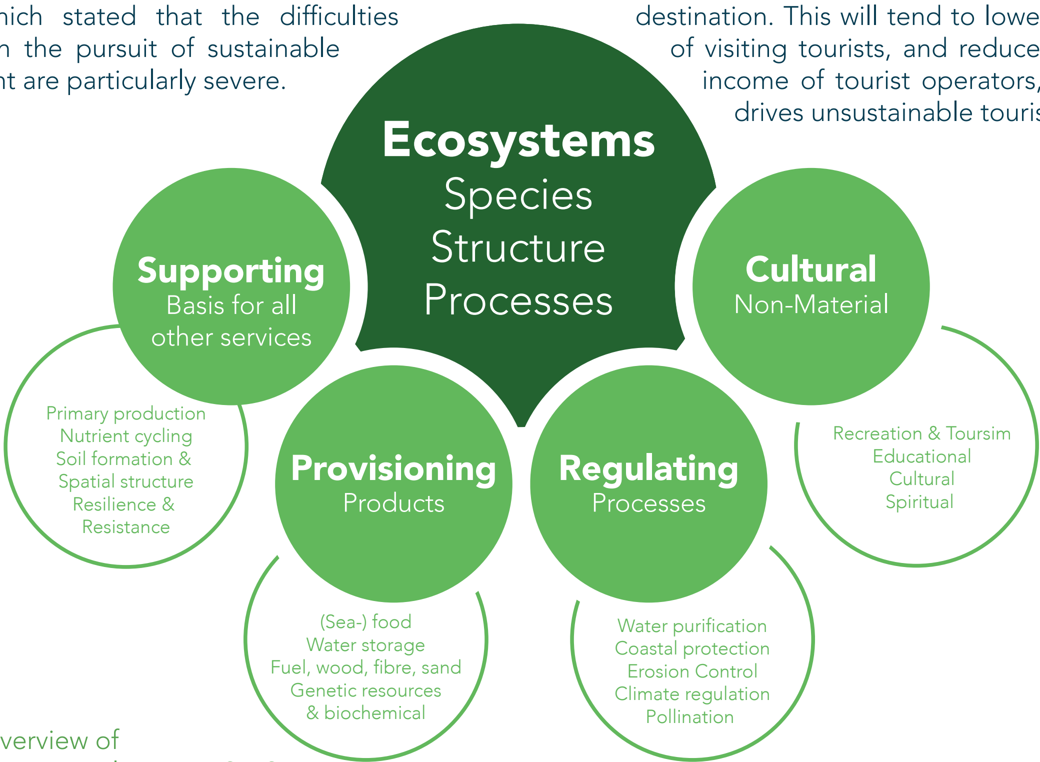

Figure 2. Overview of ecosystem services relevant to SIDS

Moreover, as most SIDS are located in tropical and sub-tropical oceans, their climate is strongly influenced by large-scale ocean-atmosphere interactions. These often manifest themselves in extreme weather events such as hurricanes and cyclones. Such phenomena are associated with storm surges, coral bleaching, inundation of land, and erosion, incurring high costs of damage to socio-economic and cultural infrastructure (Sem, 2007). Due to fears of a recurrence of similar natural disasters, investors can become hesitant, which holds back economic development, leading to increased poverty, which eventually will make the local community less resilient to deal with any subsequent natural disaster.

The WFEE Nexus approach as intervention for SIDS

We suggest that SIDS must shift from resource-wasteful technologies and practices to integrate the Nexus approach in policy planning and programming, in order to maximize resources and opportunities for efficiencies, cost effectiveness and sustainable growth. Strategies will need to include proper appraisal of natural capital, utilizing renewable energy resources and using size and scalability in SIDS as an advantage for the creation of new models of green development and sustainability. As such, regional approaches should be deployed to create economies of scale, based on the development of agricultural systems which have low energy and water demands, and which fit within the context of the environmental limits and possibilities.

At the core of the 'Nexus approach' is the recognition that water, energy, food and other resources are limited and that they are interlinked in a complex web of relations linking resource use and availability (Hoff 2011). Based on existing literature (Boto & Biasca 2012, UNEP 2014, Dodds & Bartram 2016), we identified the main Nexus interlinkages for SIDS which are presented in Box 1. below.

Box 1. Overview of main Nexus interlinkages between Water, Food, Energy and Ecosystems that are relevant to SIDS

Nexus interlinkages	Water	Food	Energy	Ecosystem
Water	Water stressed. Relatively small watersheds, limited precipitation constrained to wet season only, high evaporation. Water mainly produced out of seawater, which is a costly process resulting in water being relatively expensive	Irrigation of food/feed crops, drinking water for livestock, food production and processing, production of fertilizers. Amount of water stored in reservoirs, its management and the price of water determines yield production and price.	Water reservoirs can be used for hydropower generation, power plant cooling, drilling/ mining and refining fuels, fuel transportation in pipelines, Ocean Thermal Energy Conversion (OTEC)	Habitat loss due to water run-off and subsequent eutrophication and sedimentation of water bodies and coastal zones, changes in the ability to support biota and biological communities, due to changes in availability and quality of water
Food	Choice of crops, irrigation systems, and expansion of irrigated areas determine the demand of water for irrigation. Crops can create microclimate (shadow, less evaporation, rooted zone storing water in sediment) and as such increase groundwater volume, while crops can also reduce erosion-related water run off	Excessive dependence on imported food and hence vulnerable to global developments. Heavy dependence on coastal and marine resource for food security	Production of first generation biofuels by combustion of food waste	Habitat degradation, fragmentation and destruction due to expansion of agriculture, fisheries and aquaculture. Pressure on available water and land for nature. Soil degradation (erosion, compaction), sediment run-off and sedimentation, pollution from pesticides, fertilizers, manure, antibiotics etc., declining population sizes of wildlife, reduced biodiversity and ecosystem resilience
Energy	Energy demand in water pumping, production and distribution of drinking water, waste water treatment	Use of energy for food production, processing and transport. Prices relatively high due to dependency on import of fossil fuel	90% imported fossil fuels; vulnerable to oil price fluctuations	Habitat loss due to deployment of power plants and fuel extraction, soil and water pollution from fuel extraction, oil spills, pipeline leaks etc.. Air pollution from fuel combustion
Ecosystem	Provides ecosystem services such as water purification, recycling of nutrients, water flow regulation, energy buffer and erosion prevention, reduced evaporation of water by vegetation, storage of water by vegetation.	Biophysical support for crop and livestock production, fisheries and of aquaculture. (Micro-) climate regulation, pest management, support for pollination of crops by wildlife (i.e. insects, birds, bats)	Biophysical support for biofuel crop and biomass production. Ecosystem service of carbon sequestration (mitigating waste from energy sector)	The tendency to have high degrees of endemism and levels of biodiversity, but the relatively small numbers of the various species impose high risks of extinction and create a need for protection

Bonaire case study

Our case study focuses on Bonaire as a "demonstration" island for the nexus approach. Bonaire is a southern Caribbean island and part of the Dutch Kingdom and exemplifies many other small tropical islands in the Caribbean and elsewhere. Bonaire is not officially defined as a SIDS by the UN, but has features that do apply to the concept such as small but growing populations, limited resources, remoteness, susceptibility to natural disasters, excessive dependence on international trade, and fragile environments. It was recognized by commission Spies (Spies 2015), that the economy of Bonaire is small-scale and vulnerable because of the dependence on a limited number of sectors (Box 2). The conclusion was that to be more self-supporting and to be able to cope with future challenges, several interventions are needed. It is not only important to preserve and strengthen existing sectors, but also to exploit opportunities for diversification of sectors (Spies, 2015).

Bonaire is currently being confronted with an increasing population via immigration and increasing numbers of tourists visiting the island. Moreover, it is totally dependent on the import of food, the production of water and electricity from fossil fuels, which all result in high costs. Since the recent socio-economic turmoil in Venezuela, cheap import of fruits and vegetables has proven undependable. Furthermore, inhabitants rate life quality on the island as poor, whereby the combination of dietary habits and cost of living worsen health problems (Spies, 2015).

As is the case for many other tropical islands, the tourist economy of Bonaire is vulnerable, depending mainly on its limited and vulnerable natural marine resources. Tourism-related coastal development puts pressures on ecosystem resilience through habitat loss, waste production, and water and energy use, enhancing feedback loops with negative consequences in the nexus.

The island's agriculture is currently insufficient to secure food supply (99% of the food consumed is imported), while water supply is dependent on the desalinisation of seawater, which is a very energy consuming and thus costly process. The current practice of extensive unmanaged animal husbandry leads to overgrazing, deforestation and disruption of the hydrological cycles. This in turn leads to loss of topsoil (erosion), reduced groundwater replenishment, desertification, extinction of plant species and the loss of biodiversity. The runoff of sediments and nutrients due to overgrazing and coastal development have contributed to severe deterioration of the island's fringing coral reefs and mangrove habitats, which are the main attraction for the tourism industry and crucial to the island's economy. To make matters worse, climate change presents exacerbating challenges to Bonaire because of its small geographical area and generally low altitude. The associated challenges from sea-level rise, altered rainfall patterns, and storm-surges form major threats to long-term sustainable development.

Box 2. Socio-economical background information about Bonaire (CBS, 2018)

Size	288 km2
Population size	19500 (2018) – increase of 25 % since 2010 (migration main factor)
Population density	68/km2
Disposable income (mean)	24.1 thousand USD/household
Unemployment rate	6.9
Trade deficit	202 million USD
gross domestic product (GDP)	434 million US dollars (2016), tourism accounts for 16.4 % (2012)
GDP/capita	was 22,500 USD (2016)
Consumer price index	>103 (compared to 2011)

Governance and policy framework Bonaire

The relevant policy and governance framework for Bonaire is complex. International, regional, local en Dutch policies apply. In this factsheet these are not discussed in detail. In short, Bonaire, are Dutch overseas 'public entities'. Responsibilities and authority are divided between the Island Government themselves and the National Government by means of the National Office for the Caribbean Netherlands (Rijksdienst Caribisch Nederland). The Caribbean Netherlands of which Bonaire forms part, largely has its own laws and regulations, called BES-laws. Nature and fisheries regulations have largely been taken over from the former Netherlands Antilles. Various International Treaties and Conventions to which the Kingdom of the Netherlands is a signatory party also apply to Bonaire. Many obligations under international agreements have been incorporated into national legislation applying to these Dutch overseas entities. The Dutch National Government and the (local) island government are primarily responsible for (nature) policy and its implementation. Additionally, several government commissions and many non-governmental parties are also active in management implementation at various levels. Joint, multisectoral goal setting and proper coordination and cooperation are the key to success in all sectors.

Key stakeholders (not complete)

- The people of Bonaire
- RCN
- OLB
- LVV
- Dutch ministry of EZ and IenW
- STINAPA
- TCB (Tourism Corporation Bonaire)
- BONHATA (Bonaire Hotel and Tourism Association)
- SELIBON (Servico di Limpiesa, Boneiru)
- WEB
- Cargill
- PISKABON
- Local NGO's and SME's

The Spies Committee (2015) noted that given the small scale of Bonaire and the limited available capacity it is difficult to sustainably guarantee the quality of management and the associated official organization. The situation is too dependent on the effort and quality of individual people. As a result, the administrative power can vary considerably between successive Executive Councils (Spies, 2015). Moreover, governmental instability due to rapid changes of executive councils does not contribute to the continuity needed for structural follow-up of decisions, effective implementation and results for society (Spies, 2015). An observed common thread in the discussions in the various organizations was the lack of shared island vision and guidance, which often are the root cause for the absence and / or the delayed implementation of decisions and policy within these organizations. Given organisational malfunctioning at some governmental departments, The Netherlands appointed a so called "Bestuurs akkoord", in which agreements were reached for additional funds and investments. Allocated funds formed part of the so-called "regio envelop", directed towards setting up and strengthening primary sector projects in order to improve local food production.

Key international policies relevant for Bonaire

At international level

- UN sustainable development 2030 agenda (SDG's), in particular goals number 1, 6, 7, 8, 9, 11, 12, 13, 14, 15, 17 (in context of the nexus)
- RAMSAR Convention on wetlands
- Convention on Biological Diversity (CBD)
- the Bonn Convention (or the Convention on Migratory Species of Wild Animals (CMS)
- CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora)

At regional level

- Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC).
- Cartagena Convention (for the Protection and Development of the Marine Environment of the Wider Caribbean Region with the SPAW Protocol (concerning Specially Protected Areas and Wildlife)

At local level

- Nature Conservation Framework Act BES [Wet grondslagen natuurbeheer en -bescherming BES].
- The Fisheries Act BES [Visserijwet BES] and the Maritime Management Act BES [Wet Maritiem Beheer BES]
- Public Housing, Spatial Planning and Environmental Protection Act BES [Wet VROM BES]
- Various regulations aimed at water, energy, nature, marine park, waste etc.

Factsheets

In the following part of this document, a series of factsheets will be presented to summarise various Nexus interventions on Bonaire (see Box 3). In these sheets, current and desired state is described, including the challenges, and possible nexus solutions. Special notes on governance issues are made.

Input for the various fact sheets was obtained based on a review of prior literature and the results of workshops and meetings (held between 14-10-2018 and 19-10-2018) with various organisations on island (see Box 4).

Box 3. Overview of factsheets per Nexus domain

1	Introduction	Matthijs van der Geest[1] & Diana Slijkerman[1]	Dolfi Debrot[1]
2	Water	Diana Slijkerman[1], Matthijs van der Geest[1] & Sander Mücher[2]	Dolfi Debrot[1]
3	Food from the ocean	Dolfi Debrot[1] & Sander van der Brug[3]	Diana Slijkerman[1] & Martin de Graaf[1]
4	Food from the land	Matthijs van der Geest[1] & Diana Slijkerman[1]	Dolfi Debrot[1]
5	Energy	Matthijs van der Geest[1] & Iago Teles[4]	Diana Slijkerman[1]
6	Ecosystems	Diana Slijkerman[1], Dolfi Debrot[1], René Henkens[2], Matthijs van der Geest[1] & Sander Mücher[2]	Erik Meesters[1]
7	Tourism	Diana Slijkerman[1] & René Henkens[2]	Matthijs van der Geest[1]
8	Remote sensing tools	Sander Mücher[2], Nafiseh Ghasemi[2], Henk kramer[2], Wouter Meijninger[2] & Bert Lotz[5]	Bert Lotz[5]

1: Wageningen Marine Research, 2: Wageningen Environmental Research, 3: Wageningen Economic Research, 4: Wageningen Food & Biobased Research, 5: Wageningen Plant Research

Box 4. Organizations that were consulted for input for the various factsheets presented in this document

Organisation	Type	Persons	NEXUS domain
Stinapa	NGO	Wijnand de Wolf, Leonell Martijn, Sabine Engel, Paolo Bertoul, Caren Eckrich	Ecosystem
Nature 2	Consultant	Kally de Meyer	Ecosystem
OLB	Government	Frank van Slobbe, Dianne Boelmans	Ecosystem, Water, Energy, Food
WEB	Water and energy company	Hans Staring, Arthur Janga	Energy, Water
RCN	Government	Paul Hoetjes, Yoeri de Vries	Ecosystem, Water, Energy, Food
LNV	Government/policymakers	Hayo Haanstra	Ecosystem, Food
Chamber of Commerce	Government	Gianni Marie van den Heuvel, Dick Ter Burg	Tourism
TNO	Research	Kris Kats	Ecosystem, Energy
Boneiru Duraderu	Local small scale initiative/ sustainable project coordination	Sharon Bol	Ecosystem, Water, Energy, Food
Zilte landbouw Texel	Entrepreneur	Marc van Rijsselberge	Water, Food
Wageningen UR Livestock Research	Research	Francesca Neijenhuis	Ecosystem, Food
Wayaká Advies	Consultant	Jan Jaap van Almenkerk	Water, Food

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Colophon

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The KB program “Nexus Strategic policy case”, included a Bonaire NEXUS case study. The case study was funded under KB-33-005-013, and administered under project number 4318300087. A letter report (number 1900369.ds) summarises the activities. In the study a set of 8 factsheets was drafted (and attached to the letter report). The set of factsheets can be found on : www.wur.eu/sustainablewatermanagement
factsheets was drafted which can be found on : www.wur.eu/sustainablewatermanagement