

Transition management as a tool for the governance of the water-energy-food nexus in Bonaire

Oliemans, J.B.¹, Quist, J.N.², Kunneke, R.W.³

Abstract

The island of Bonaire is planning multiple sustainable transitions in the water, energy and food systems in response to numerous challenges, such as increasing population pressure, rising sea levels, environmental damage, high consumer prices and import dependency. The water-energy-food nexus is a relatively novel concept that takes an integrated approach to resource security and sustainability. This paper applies systems theory and transition management theory to a water-energy-food nexus approach in Bonaire and proposes three pathways to reach an integrated sustainable transition in Bonaire's water, energy and food systems. It shows that this approach can provide valuable insights for the integrated governance of the water, energy and food systems.

Keywords: WEF-Nexus, Transitions, Governance, Pathways, Systems analysis, Bonaire

1. Introduction

Small Island Developing States (SIDS) are facing common challenges exacerbated by climate change. Their limited size, increasing population and a growing tourism industry lead to increased population pressure [1]. Many SIDS are facing water and food scarcity, as they often rely on one source of fresh-

¹Faculty of Technology, Policy and Management, Delft University of Technology, Jaffalaan 5, Delft, the Netherlands, j.b.oliemans@student.tudelft.nl

²Faculty of Technology, Policy and Management, Delft University of Technology, j.n.quist@tudelft.nl

³Faculty of Technology, Policy and Management, Delft University of Technology, r.w.kunneke@tudelft.nl

water and almost all food is imported [2, 3]. Fossil fuels have to be imported, resulting in high electricity prices for consumers. SIDS experience significant vulnerabilities to the effects of climate change: sea level rise threatens their territory, rising sea temperatures degrade the ecosystems which provide food and attract tourists and natural disasters are occurring more frequently and with greater impact [4, 5, 6]. Recognition of and attention towards these adversities has grown over the past 25 years. Multiple international proceedings have resulted in development programmes that are specifically focused on SIDS [2]. These international proceedings recognise that poverty eradication, sustainable production and consumption patterns, and protecting and managing the natural resource base are the essential requirements for achieving sustainable development in SIDS. Nevertheless institutional capacity is SIDS often poor, complicating development programmes.

The island of Bonaire is experiencing many of the common challenges for SIDS. It is located in the Leeward Antilles, a group of islands located in the south-east region of the Caribbean sea. Its population has increased with 28% between 2011 and 2019 and is expected to increase another 23% between 2019 and 2025 [7]. Its dependency on food and fuel imports is high. This results in high consumer prices for its residents. Its remoteness and limited resources decouples Bonaire from larger trade networks, as well as hampering the opportunities for economies of scale [2, 8]. Domestic pollution factors resulting from extensive fossil fuel use and waste problems contribute to their environmental vulnerabilities [9]. Its economy is overly dependent on tourism [10]. Furthermore human capacity and knowledge to tackle these threats is limited and can vary heavily between successive governments [11]. In response to these challenges the OLB, Bonaire's governing body, has set multiple agendas for sustainability transitions in the water, energy and food systems. Initiating these transitions in the water, energy and food systems risks that important connections between the systems are overlooked, however. Instead of tackling each sustainability transition in isolation, a relatively novel concept called the *water-energy-food nexus*

may provide valuable insights for Bonaire and SIDS in general with achieving their transitions towards sustainability [12].

The reduced size, complexity and the isolated nature of SIDS may better facilitate the implementation of a nexus approach, contributing towards its proof of usefulness and practical value, which is currently contested [12, 13, 14, 15]. Systems theory and transition management theory are used to investigate the opportunities for a sustainable transition in the water-energy-food nexus in Bonaire. First a methodological approach is presented that builds upon the Transition Management Cycle [16]. This approach is applied to a case study for the island of Bonaire. A shared vision is constructed and transition pathways proposed that work towards the shared vision. Finally a discussion and conclusion regarding the WEF-nexus in Bonaire are presented.

2. The water-energy-food nexus

WEF-nexus thinking has previously been concerned with resource efficiency and the optimisation of resource flows between water, energy and food. This has neglected the political aspects of resources [17]. Decisions and actions regarding natural resources are often politically charged, take place in a contested environment and create conflict through intense competition for resource access [13, 18]. When attempting to implement nexus policies, governments are faced with the complexities and uncertainties the nexus inhibits, such as the challenges of working across different scales [19], defining responsibilities amongst different governmental agencies and the increased possible configuration of solutions and policies [20]. The usefulness of the WEF-nexus as a framework must be to explore alternative pathways instead of legitimising existing dominant pathways [17].

There are a number of similarities between systems theory and the WEF-nexus that make systems theory a valuable approach worth taking. The WEF-

nexus emerged from the acknowledgement of multiplicity and interdependence between the water, energy and food systems. In systems theory the belief is held that the performance of a system cannot be optimised by optimising its subsystems in isolation from one another [21]. This corresponds with the origin of nexus thinking: that water, energy and food policy can create unintended consequences when designed in "silos". Furthermore, no single definition or optimal solution exists within the nexus. Rather, it is a constant interaction between stakeholders to form synergies and trade-offs between the systems. When adopting a systems perspective, a researcher analyses a situation as a *complex system*. A complex system is constrained by certain boundaries and comprised of technical artefacts and institutional and social entities. Within a complex system multiple smaller subsystems exist that are connected and embedded, producing a large number of uncertainties. Its behaviour is non-linear and unpredictable [22]. A lack of understanding of the properties of a complex system can prevent the design of effective cross-system policies [21]. Henceforth interventions in complex systems can produce unintended consequences resulting from its connectedness and dynamic strategic behaviour from individual stakeholders.

From a nexus perspective, the goal is to achieve an integrated and coordinated transition towards sustainability in the water, energy and food systems. Transitions are processes of transformation where a regime and its rules and regulations, culture and practices are undone and new regimes are created [23]. Transition management (TM) theory is closely related to systems theory and is suited as a normative approach in developing governance strategies to reach desirable futures [16, 24]. Both systems theory and TM are multi-disciplinary and acknowledge that technical analysis is insufficient to address complex problems, and that analysing social, institutional and economic factors is imperative to decision making. Similar to the critique the WEF-nexus receives for being too much focused on optimisation and neglecting the social structures underlying resources, Loorbach (2017) sees that "From a transition perspective, sustainable development policies and programs have focused too much on reducing unus-

tainability through optimisation, thereby (un-willingly) adding to the lock-in of societal systems” [24]. First, TM allows for the analysis of incumbent stakeholders and governance structures by conceptual methods such as the Multi-Level Perspective. This is of importance in the WEF-nexus in order to successfully address inequalities in the nexus [17] and to achieve successful cooperation and coordination between different stakeholders [25]. Second, TM provides methods designed to guide transitions towards a desirable future that is shared amongst stakeholders, such as the Transition Management Cycle [16]. The realisation that the WEF-nexus has to take into consideration the political-economic factors that often dominant stakeholders enforce, makes TM a potentially suitable approach and one that is underrepresented in current literature on the WEF-nexus.

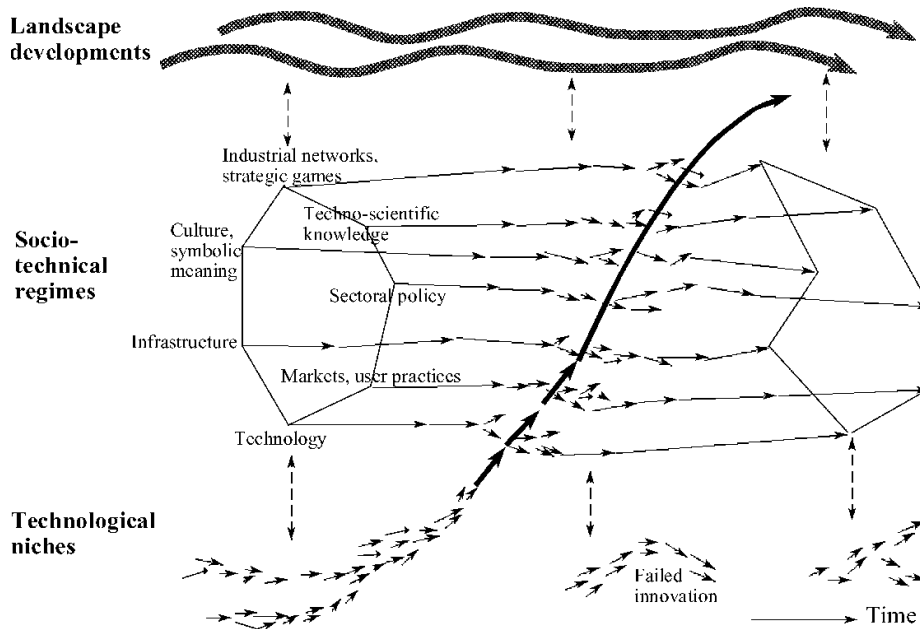


Figure 1: Multi-Level Perspective [26]

2.1. Transition management theory

The Multi-Level Perspective is a popular framework to understand the dynamics of socio-technical transitions (figure 1). It supposes that transitions arise from the connections between the niche, socio-technical regime and exogenous socio-technical landscape [27]. Niches are relatively isolated and safe spaces where new technologies or social practices can develop and accumulate traction and where some are eventually able to influence the dominant socio-technical regime. On the regional and national level, a key barrier to successful nexus governance are the historically entrenched vertical government structures [13]. Geels (2014) define these entrenched structures as a regime: a complex heterogeneous system that includes both technical artefacts and human stakeholders, is stable, resilient and capable of self-reproduction potentially leading to technological lock-ins [27]. The technical artefacts in socio-technical systems, rules, regulations, and routines and behaviour are 'locked-in' and prevent structural change [23]. Lock-in is relevant for understanding and governing transitions in the WEF-nexus [28]. Particularly the water and energy systems are influenced by previous investments in infrastructure, generation capacity, rules and behaviour. The third and final concept is the landscape. In the socio-technical landscape global forces and paradigms develop, which in turn are able to pressure the regime. Examples of landscape pressures on the WEF-nexus are rising sea levels threatening fresh-water supplies, volatile oil prices and increasingly extreme weather influencing food production.

The WEF-nexus adds another dimension to the three levels in transitions, namely that the distribution of power between different systems can vary significantly. For instance, a well-established locked-in regime in the water system can exert far greater amounts of influence than a still emerging regime in a developing food system. This is often the case in SIDS, where water production and distribution organisations are predominantly public companies with large market power and close ties to the governing bodies, whilst stakeholders in the agriculture system have less means and are underrepresented. Differences in the

power of regimes and niches amongst systems has major implications and can create suboptimal and unequal solutions [29].

Visions can create a desirable future system state for the transition process to strive towards and find common goals between different stakeholders. Shared basic principles for long-term sustainable development can form a basis for sustainability visions [16]. A clear need for change must be present to warrant visions. This need has been demonstrated by the rising water and food prices, population, poverty and the degrading capacity and quality of the current electricity network in Bonaire [30]. Visions are used in transformational change, to replace old structures by new ones [31]. Emerging visions stem from different beliefs, values and mental frameworks typically associated with outsiders and not with larger societal groups [32]. The WEF-nexus itself can be seen as a new emerging vision that attempts to replace the old structures of governing critical resource systems and can be placed in the niche developments. Not only emerging visions in the water, energy and food systems and the stakeholders providing agency to those visions is relevant to a transition in the WEF-nexus, but also emerging visions regarding the WEF-nexus.

3. Methodology

To analyse the governance of the water, energy and food systems in Bonaire and find strategies for an integrated sustainable transition, the strategic phase of the Transition Management Cycle (TMC) (figure 2) is selected. The synthesis of multiple theories and fields of study (the WEF-nexus, systems theory, transition management) has multiple methodological implications. First, the combination of the WEF-nexus and transition management theory has implications on the scope of the research. The water, energy and food systems are not only connected with one another, multiple other pressures exist that influence these systems. From an isolated systems perspective, these pressures might be

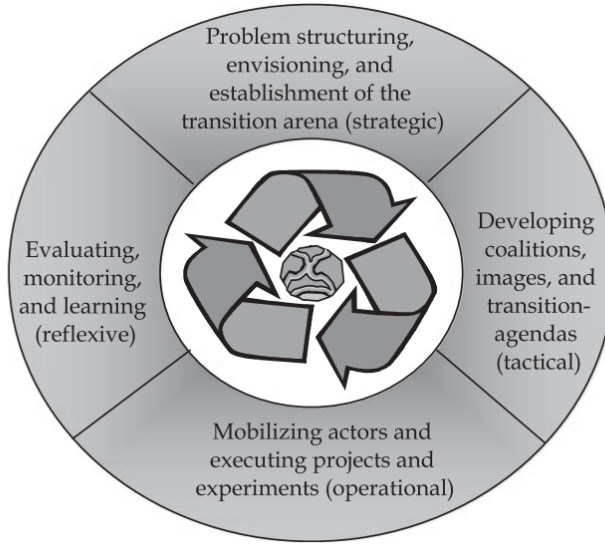


Figure 2: Transition Management Cycle [16]

left out of the scope, or accounted for as external pressures. Yet this risks that the political economical environment within and surrounding the WEF-nexus remains underrepresented. Furthermore, transition management theory argues that a narrow scope can create a lack of attention for important factors and alternative perspectives [23]. Thus, a wide scope of this research aims to prevent overlooking key factors from the political economical environment and potential transition opportunities, but adds difficulty to the research [33]. The second implication is that a selection of methods from systems theory and transition management theory has to be made that is able to address the nexus' knowledge gap and provide recommendations for Bonaire. This results in a methodological framework that is specified towards the attributes of the WEF-nexus and its missing a political-economy focus. Third, the extensiveness of these selected methods is affected by the focus on three socio-technical systems instead of one and the wide scope. The proposed added value therefore, lies in the synthesis of multiple different methods.

1. Problem structuring	
<i>Step</i>	<i>Methods</i>
1.1 Systems analysis	[34]
1.2 PESTLE analysis	[35]
1.3 Stakeholder analysis	[34]
1.4 Governance	
1.5 Vision classification	[36]
1.6 Cross-case analysis	[26]
2. Envisioning desirable futures	
2.1 Delineate vision space	
2.2 Construct shared vision	
3. Designing the transition arena	
3.1 Explore transition pathways	Multi-Level Perspective [27]
3.2 Recommend transition agenda	Transition Management Cycle [16]

Table 1: Theoretical framework (based on the strategic phase of the TMC [16])

In the problem structuring step, a selection of systems theory methods [34] is used to analyse the socio-technical complexities, identify relevant factors for the Multi-Level Perspective, analyse relevant stakeholders and create insight in the governance structures of the water, energy and food systems. A vision classification framework [36] is used to structure published stakeholder visions and sketch the shared vision space. A cross-case analysis is used to find similarities and differences between the three systems that are relevant for integrating governance of the three systems. The outcomes of the systems theory methods are used to map the current cross-sector governance processes from a transition management perspective. In the envisioning phase the shared vision space is delineated, shared common principles for the future are identified and a desirable future for Bonaire is constructed from the published stakeholder visions. In the establishment of the transition arena transition pathways are proposed

that work towards this shared vision. Finally recommendations are presented for the continuation of the Transition Management Cycle. Table 1 presents the proposed theoretical framework applied in this research.

4. Case study

The high number of elements and non-linear interactions in particularly the food system, but also in the water system, lead to complex behavioural dynamics. While the energy system has less elements and feedback loops, it is nevertheless a highly technical system, resulting in external knowledge and capacity being necessary for its development [37, 38]. Bonaire’s small scale is beneficial for the technical operations of the energy system, but the lacking economies of scale and high consumer prices constrain the water and food systems. Furthermore the water and food systems are strongly connected. Decisions made by stakeholders in one system can be expected to have consequences in the other systems and an awareness of the connections may thus help prevent unintended effects. This is particularly relevant for the food system, which is in development and has experienced bad governance in the past, particularly in the case of free-roaming goats. Knowledge of the negative feedback loops and non-linear interactions by governmental agencies and other agents, such as farmers, can help prevent negative consequences for ecological health and water resources. The energy and water system are governed by a connected regime of multi-level governmental agencies such as the OLB and the Ministry of Infrastructure and Water Management, and public and private companies such as the Water and Electricity Company Bonaire (WEB) and Contour Global Bonaire (CGB). Historic investments in the water and electricity production capacity and distribution infrastructure have locked the regime in place, offering an explanation why novel technologies such as ocean thermal energy conversion and distributed water generation have found no support. Water and electricity prices constrain the operations of the OLB and the WEB, as this issue is high on the political agenda in Bonaire. Developments in the governance of the water and energy

systems are primarily concerned with tariffs and daily operations of the infrastructure. Security of supply is prioritised and sustainability is only a part of the mindset of the WEB [39]. The food system is far behind the water and energy systems in terms of professionalisation, economic opportunities, knowledge and political power. The food system is strongly connected with the water and energy systems. Stakeholders in the food system are dependent on the regime stakeholders in the water and energy systems, such as the WEB and Bonaire Hotel and Tourism Association (BONHATA), in achieving their goals. Multiple barriers need to be overcome for a sustainable transition. For the OLB the development of human capacity, increasing executive power and knowledge and basing decision-making on data rather than intuition is necessary. Affordable consumer prices and security of supply are critical goals to fulfill in the future as population and tourism numbers grow, and constrain expensive investments in infrastructure. Subsidies remain necessary for the treatment of wastewater and the attractiveness of agriculture. Multiple laws and the regulations set out in the Spatial Development Plan provide the OLB with a legal framework to reduce environmentally damaging activities and better design the rural areas. The data and knowledge that can support better design regarding ecosystem dynamics such as groundwater flows, is not available however.

The WEB, the OLB and the RCN, whom coordinates the efforts of multiple ministries, are all central parties in the governance of the water, energy and food systems. These parties cooperate and communicate often as a result from Bonaire's small scale: one quickly enters the domain of other stakeholders. Stakeholders also cross system lines: the WEB is a regime actor in both the energy and water system, and has an increasingly influential role in the food system through the production of treated wastewater. The water, energy and food systems are all facing increasingly complex governance issues as new technologies and products emerge, such as private solar PV growth, aquaculture and algae. Furthermore stakeholders are increasingly aware of the existing and growing connections between the water, energy and food systems. The biggest

bottleneck found to effective nexus governance is the lack of political vision and long-term commitment and stability. The technological solutions to problems in the WEF-nexus are available, but transforming pilot projects from technological niches into the mainstream with secure financing often fails. From this it can be concluded that the regime parties are often willing to engage in sustainability transitions, but this happens on their terms and the quality of governance is low, particularly in long-term project development.

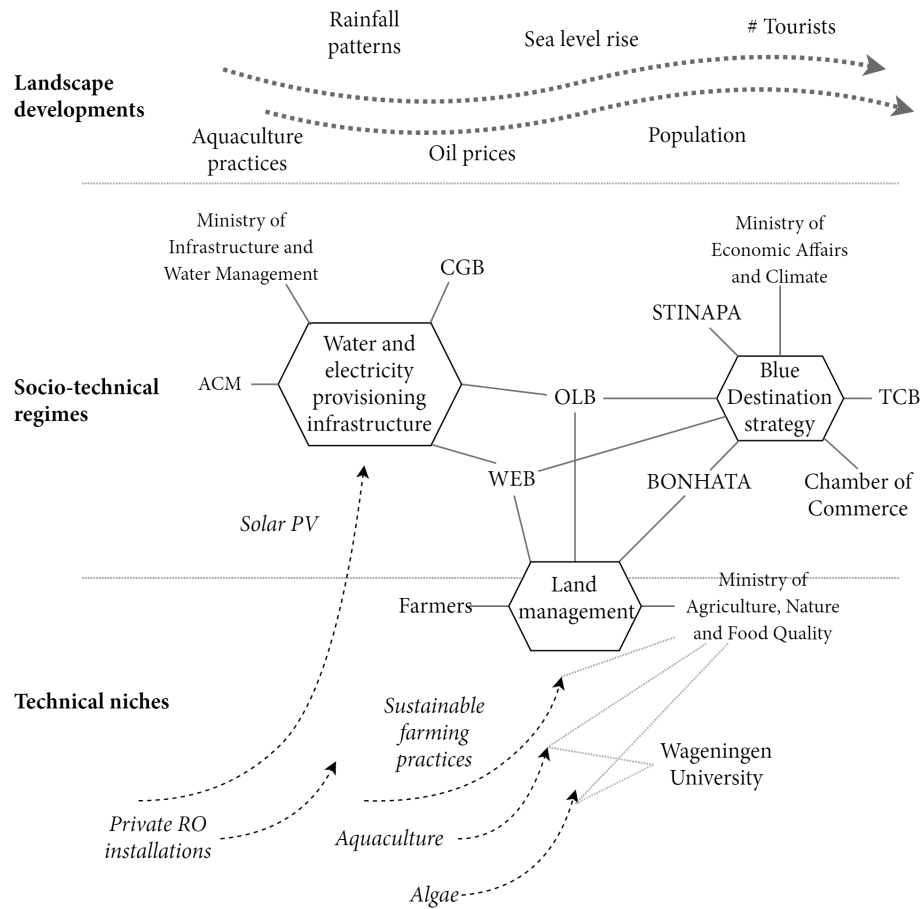


Figure 3: Multi-Level Perspective on Bonaire

A new technological niche around land management practices is slowly evol-

ing and pressuring the socio-technical regime. It is spearheaded by a small amount of farmers and the Ministry of Agriculture, Nature and Food Quality in their policy goals of professionalising the food system and increasing local production. Wageningen University assists in maturing the agricultural practices and new technologies such as algae to be economically feasible on a larger scale. Policies regarding reforming land use and contributions to land degradation are complicated, and besides the Spatial Development plan no plan exists that addresses and combines water management, suitable locations for agriculture, renewable energy and tourism development [12, 40]. Integration as a new socio-technical regime will depend amongst others on the nature of the relationships formed with the OLB, WEB and BONHATA (figure 3).

5. Transition Pathways

Multiple published visions were analysed for the water [10, 41, 42, 43], energy [10, 30, 39] and food [10, 41, 42, 44, 45, 46] systems. Certain developments in Bonaire, in particular the Blue Destination strategy, are related to the technical and governance aspects of the water, energy and food systems. This has implications on the scope of the shared vision, as certain elements are included that may at first not seem relevant to a sustainable transition in the water, energy and food systems, but are to be included if important transition barriers are to be overcome. Based on these published visions and transition barriers and opportunities a shared vision for Bonaire can be constructed (figure 4). The shared vision represents a future where a sustainable transition of the water, energy and food systems is achieved. In this future Bonaire is able to effectively govern the relationships between the water, energy and food systems, the tourism industry and its environment to provide a high quality of life for its residents.

Three pathways sketch different trajectories that strive towards the shared vision. These are: 1. Human capacity and innovation development, 2. Ecosystem management plan and 3. Sustainable tourism.

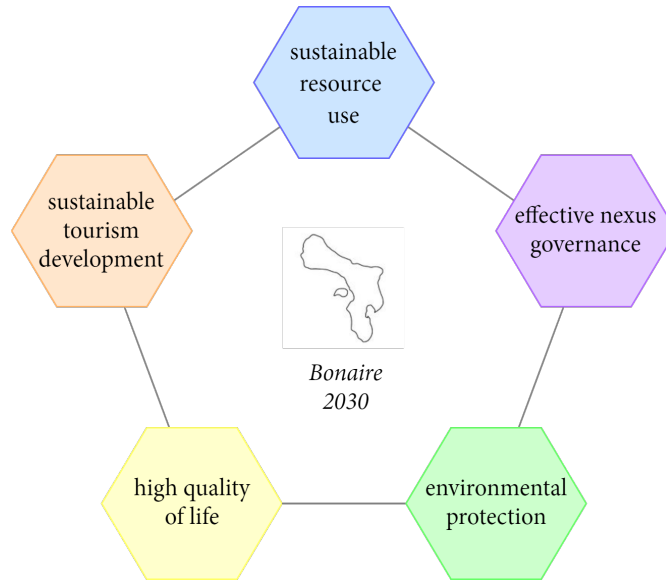


Figure 4: A shared vision for Bonaire's future

5.1. Human capacity and innovation development

This pathway originates from multiple policy documents, visions and interviews that mention increasing human capacity in a wide variety of organisations. This pathway will focus on increasing human capacity in Bonaire in regards to project planning and execution, innovation management and knowledge dissemination. Individual human capacity development programmes are brought together under a WEF-nexus umbrella where the focus lies on collaboration on cross-sector projects. As stated by Reinhard (2017), when the synergies and trade-offs between the nexus systems are identified in the design and implementation of policies, plans and investments, policy coherence is increased [14]. Linking human capacity development to a public investment programme, such as the investment fund created by the Ministry of Agriculture, Nature and Food Quality, or a private investment fund such as the microfinancing programme run by the NGO Qredits, can encourage learning by doing, an established practice within transition management [14, 47]. Stimulating and facilitating innovation management through developing human capacity can help promising technolo-

gies such as biofuels and high-tech vegetable and fruit production break through into the socio-technical regime. Given that the majority of stakeholders with human capacity plans are active in either the water and energy provisioning regime and/or the Blue Destination strategy, central steering of the human capacity development programmes risks capture by the socio-technical regime. Capture could steer learning away from nexus governance and innovation management towards conventional thinking and the continuation of regime practices. To connect all the capacity programmes and implement a WEF-nexus perspective, an independent process facilitator is recommended.

5.2. Ecosystem management plan

A large loss of the value of ecosystem services is expected if no actions are taken to protect Bonaire's environment [48]. Multiple sectoral reports advocate better practices that limit the negative ecological and economical consequences for the socio-ecological system [49]. There is a lack of data on ecosystem components such as groundwater dynamics, fish stocks, habitats, biodiversity and coastal erosion. The first step in this pathway is to gather knowledge on the functioning and connections of the ecosystem and its resource systems. Shared fact finding is recommended as a process to increase the acceptance and objectiveness of the gathered data and to reduce the risk of multi-interpretation of principles by stakeholders from different backgrounds [12]. Second, a participatory process is developed to construct the ecosystem management plan where sustainable ecosystem use is the main goal. Third the restoration of beneficial infrastructure such as irrigation infrastructure, rural septic tanks and the replanting vegetation and coral is undertaken. Continuous ecosystem governance and enforcement of rules and regulations by the OLB is necessary, as historical evidence has shown that lack of enforcement leads to harmful consequences for ecosystem health [50]. Three laws have to be fully utilised by the OLB in this pathway: the Fishing law BES, the Law Public Housing, Spatial Planning and Environmental Management BES 2017 and the Law Nature Conservation and Protection BES 2019. These laws provide the legal framework wherein the

ecosystem management plan can be drafted, enforced and updated every five years.

5.3. Sustainable tourism

Bonaire has a history of environmental protection which results in healthy and high quality natural assets that attract tourists. Tourism has been a major part of Bonaire's economy for decades. The Blue Destination strategy is the initiative that responds to the long existing wish to transform the tourism industry, increase the value of tourism to the local population and protect Bonaire's natural assets. In this pathway sustainable tourism is used as an engine for growth. More soft tourism experiences are developed that are less dependent on the environment, require less investments in infrastructure and provide economic opportunities to the residents of rural areas. Initiatives already exist that combine tourism with environmental engagement, such as diving schools offering coral replanting excursions and restaurants promoting recipes containing the invasive lionfish species. The development and promotion of these initiatives increases Bonaire's image and attractiveness as a sustainable destination. Sustainable transitions in the water, energy and food systems can benefit from the attention and private investments sustainable tourism generates if the transition's sustainability opportunities are beneficial to and framed within sustainable tourism. Nevertheless the sustainable tourism pathway risks the further increase of resource demand from construction activities and increased tourism numbers, also in rural areas for "eco-hotels" and rural tourism activities. This complicates the security of supply challenges that already limit the capacity for long-term planning in the water and energy provisioning regime. Furthermore the Blue Destination branding risks legitimising existing unsustainable regime practices through greenwashing and suppressing technologies and practices in the technological niche that can offer benefits to Bonaire. An example of this is the recent article in the Antilliaans Dagblad, wherein a property developer of eco-hostels in a rural area of Bonaire facing criticism for the ecological damages resulting from the proposed plan [51].

6. Discussion

In this research systems theory offered well-established methodologies and tools to compare the socio-technical complexities of the water, energy and food systems and identify transition barriers and opportunities. Transition management theory was able to address power dynamics, clusters of stakeholders influencing system behavior and the behaviour of socio-technical systems over time in a direction towards sustainability. Two arguments speak in favour of using transition management theory in a WEF-nexus approach. First, it can help in achieving a coordinated and integrated sustainability transition in the water, energy and food systems by directing its socio-technical systems towards sustainable development [47]. Second, the combination of systems analysis and transition management principles such as governance, regime constellations and rules and regulations contributed to understanding the political economy in the WEF-nexus and related sectors in Bonaire. In this regard contributions are made to the development of the WEF-nexus concept by explicitly accounting for governance structures and their implications on the water, energy and food systems. The WEF-nexus perspective is appropriate in understanding the complex challenges facing SIDS and the difficulties in solving those challenges in a sustainable manner. It is able to provide recommended pathways to integrate the water, energy and food systems from a technical and governance perspective, instead of sectoral recommendations that neglect the negative feedback loops and synergies between the systems. Sufficient attention must be given to the specific political, economical and institutional barriers that are unique to SIDS, such as lacking economies of scale, high consumer prices and lacking human capacity.

In this research only the published visions regarding the development of Bonaire could be used to find common shared principles and construct a shared vision. Stakeholder interviews provided nuance to these visions, but it remained unclear what the relative importance of certain documents is compared to oth-

ers. This risks that alternative visions that contest the status quo are not included in this research and that the shared vision is a confirmation of the goals held by the socio-technical regime. It also assumes equal importance of the visions, whereas the local influence of certain documents might be greater than others. Recommendations for future research are to increase the participatory nature of the transition management process to find alternative visions and transition pathways to the ones in this research. Parts of the methodological framework for participatory backcasting developed by Quist (2006) are valuable and applicable in committing stakeholders behind a shared vision, improving the transition pathways and engaging them in the transition management process through participatory tools [52].

7. Conclusion

In this research systems theory and transition management theory proved useful for an integrated analysis of the technical complexities, governance challenges and sustainability transitions of the water, energy and food systems in Bonaire. Multiple barriers and opportunities for a sustainable transition in the WEF-nexus in Bonaire were uncovered through the research approach. By investigating socio-technical regime structures and niche developments, relevant barriers and opportunities were found outside the water, energy and food systems that would otherwise be omitted. A shared vision was constructed for Bonaire based on the sectoral visions published in literature. The three recommended transition pathways are ways of contributing towards the shared vision. Integrated human capacity and innovation development can provide decision-makers and other stakeholders in the WEF-nexus with the knowledge, means and network to steer and connect sustainable transitions. An ecosystem management plan can be constructed within an existing legal framework and if properly enforced, lay out integrated spatial development of Bonaire's natural resource use. Sustainable tourism can provide capital, awareness, improvements in infrastructure and an increased demand for high-quality local produce if done

properly. Finally, the continuation of the Transition Management Cycle with a participatory approach can identify and engage frontrunners willing to engage in the transition arena and further elaborate the transition pathways with discussions on essential elements, resources and planning. The nature of the WEF-nexus implicates that a large number of stakeholders from different backgrounds are quickly involved and that stimulation of cooperation is beneficial under all circumstances.

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