GLOBAL CHANGE, ISLANDS AND SUSTAINABLE DEVELOPMENT

Islands of sustainability or analogues of the challenge of sustainable development?

C. Michael Hall

Introduction

Islands, and especially tropical islands, have a prominent place in the Western cultural imagination. Yet their image has undergone substantial change over time shifting from a focus on mercantile resource exploitation, to a more Romantic portrayal in the nineteenth century. In the modern era Romantic themes have often been essential to the tourism imaginary of islands for the markets of the developed world (Hall and Page 1996). More recently islands have become one of the focal points of contemporary environmental and, hence, economic and political change (Moore 2010). Images and stories of islands disappearing beneath the waves have become major symbols of global change (Hall 2010a). But more than that, they have also become both actual and symbolic representations of the central challenge of sustainable development to reconcile human demands with the limits of natural resources.

Islands are significant to help an understanding of the problem of transitioning to sustainable development because their finite space represents an analogue with that of the Earth with respect to issues of managing resource use and waste within a relatively bounded system. An important line of thinking in sustainable development is the significance of islands of sustainability (IOS) (Wallner et al. 1996; Bebbington 1997; Deschenes and Chertow 2004; Pété 2012) whereby global sustainability will be achieved when regions live according to their carrying capacity, i.e. the ability to live and develop without running down natural capital. According to Wallner et al. (1996: 1764) this means that:

In order to reach regional sustainability the area balance—taking into account the appropriated area from other regions (imports), the area actually occupied for a region’s own purposes, and the area made available for other regions (exports)—should not be negative in such a way that the appropriated area exceeds the others.

IOS are also regarded as important ‘innovative disturbances’ (Wallner and Narodoslawsky 1996) that are able to jeopardise the structural stability of unsustainable systems whether they be at a macro-regional, national or global scale, and may provide opportunities to introduce elements
of sustainable development into the wider system. Such potential shifts as a result of IOS, Wallner et al. (1996) argue, would therefore contribute to the transition toward wider sustainable development as a result of the accompanying paradigm change from a mechanistic to a holistic (synergetic, network) or integrated paradigm.

Although the desired outcome of the IOS appears optimistic, the bounded systems of the IOS approach are a potentially useful analogue to examine issues of island transition. However, real islands as well as IOS are never completely bounded (Kerr 2005). Physical flows of matter and energy extend over products, processes, and firms, and local, regional or national boundaries and borders, as well as flows of capital and people. The latter are especially important for Small Island Developing States (SIDS), given the critical role of migrant flows and remittances (UN DESA 2010). Moreover, different islands and SIDS can have substantially different political jurisdictions and governance capacities and socio-cultural structures. Nevertheless, issues of scale and relative isolation remain key characteristics of islands. The relatively ‘simpler ecologies’ of islands are also matched by their economies which tend to have a narrow base. Islands are systems that are closed and bounded in many respects and thus provide a manageable unit of research and a ‘living laboratory’ on the realities of sustainable development including with respect to scales of application and analysis (Hall 2010a; Pungetti 2012). Of course, these same properties ‘present island populations with the challenges of limited resource availability, tenuous resource security and limited natural carrying capacity’ (Deschenes and Chertow 2004: 202). Many island microstates are also among the most at risk jurisdictions from environmental change such as sea level rise, ocean acidification and biodiversity loss, as well as being some of the least developed countries in the world (United Nations Department of Economic and Social Affairs [UN DESA] 2010). As Deschenes and Chertow (2004: 202) suggest, ‘While every human population faces these challenges, the need to find solutions for sustainable development is much more immediate for island systems.’

This chapter therefore examines the main challenges facing SIDS with respect to sustainable development including climate change, a narrow resource and economic base, population change, natural disasters and biodiversity loss. At a more conceptual level, and using notions of island biogeography in particular, the chapter then examines the extent to which SIDS may serve as islands of sustainability and the insights that can be gained from island studies of the prospects of sustainable development.

**Small Island Developing States (SIDS)**

Although typically portrayed in tourism promotion as idyllic destinations with waves lapping palm-tree-ringed sandy beaches, the reality of SIDS is far more complex. The challenges of SIDS within the context of sustainable development was first formally recognised by the international community at the 1992 United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro. Chapter 17, paragraph 124 of Agenda 21 states:

[SIDS] and islands supporting small communities are a special case both for environment and development. They are ecologically fragile and vulnerable. Their small size, limited resources, geographic dispersion and isolation from markets, place them at a disadvantage economically and prevent economies of scale.

(UN DESA 2010: iii)

However, there is no agreed definition of SIDS, even within the United Nations Community. UNCTAD (2012) recognises 29 SIDS, of which eight are included in the group of 48 Least
Islands of sustainability

Developed Countries (LDCs), while the Department of Economic and Social Affairs, Division for Sustainable Development, identifies 39, two of which also qualify as LDCs (Table 3.1). The UN Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLLS) recognised 57 SIDS as of the start of 2014, 38 of which are UN members, with the remaining 19 states being either non-UN members or associate members of regional commissions.

Population growth and urbanisation

A common element with SIDS is the extent to which they have highly vulnerable economic, social and natural environmental systems as a result of their small size, narrow resource base and insularity (Kerr 2005). Many SIDS also exhibit relative remoteness from major markets, vulnerability to external shocks, and substantial exposure to global change. Such vulnerabilities are exacerbated by population increase and growing urbanisation. The percentage of the population living in urban areas across all SIDS increased 11 per cent, from 49.5 per cent in 1990 to 55 per cent in 2008 (UN DESA 2010), with urbanisation showing no signs of decrease. Because of their limited size the combination of population growth and urbanisation also leads to greater population density in urban areas. For example, Ebye Atoll, the capital of the Marshall Islands, is an island that is now 100 per cent urban and has the highest population density in the Pacific (Wilkinson 2011), at over 40,000/km$^2$ (Chui and Terry 2013).

A classic example of SIDS urbanisation is Funafuti, the capital island of Tuvalu, with an area of approximately 2.79 km$^2$. In 1973, Funafuti had 14.8 per cent of the total population and a population density of just less than 900/km$^2$. By 2002, it had grown to approximately 47 per cent of the total population with a population density of just over 1,600/km$^2$ (Wilkinson 2011).

In the Indian Ocean, the capital of the Maldives, Malé, is home to nearly a third of the country’s population and has a density of over 17,000/km$^2$ (UN DESA 2010).

Urban centres are therefore significant sites of environmental change (Connell 2011). Although high urban population densities may be interpreted on the one hand to have relieved pressure on natural habitats and biodiversity in rural areas, the impact on coastal ecosystems is intensifying in areas of urban growth, while also placing urban populations at increasing risk of disease, coastal erosion, and flooding (Donnelly and Jiwanji 2010; Wilkinson 2011; Chui and Terry 2013). For example, Betio, the capital of Kiribati, on the atoll island of Tarawa, has a population of 12,509 people on 1.45 km$^2$. Approximately 40 per cent of households are connected to the sewerage system which pumps raw sewerage directly into the sea. Those not connected use either pit latrines, small septic tanks or the beach (Butcher-Gollach et al. 2007).

Environmental change

Many low-lying small island countries are extremely vulnerable to sea level rise. The Intergovernmental Panel on Climate Change (IPCC) forecast that global sea levels will rise on average between 24 and 30 cm by 2046–2065 and between 40 and 63 cm by 2081–2100 (IPCC 2013). A large proportion of the population of many SIDS live in a low elevation coastal zone (LECZ), or the contiguous area along the coast that is less than 10 metres above sea level. Nineteen SIDS have population shares greater than 39 per cent in the LECZ with the Maldives, Bahamas, Bahrain and Suriname among those most at risk (UN DESA 2010). The situation for SIDS is further complicated by a high coastline-to-land-area ratio. This means that many settlements and critical infrastructure are increasingly vulnerable to erosion, storms and tidal surges,
### Table 3.1 Characteristics of SIDS

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### Table: Key Indicators for Various Countries

| Country                        | Region | UN | X | Y | Z | W | V | U | T | S | R | Q | P | O | N | M | L | K | J | I | H | G | F | E | D | C | B | A |
| Dominican Republic            |        | UN | X | 2.2 | 3.1 | 16.1 | 16.6 | 9 | 0.702 (96) |
| Federated States of Micronesia|        | UN | NA | 0.6 | NA | 13.7 | NA | 45 | 0.645 (117) |
| Fiji                          |        | UN | X | 1.5 | 1.0 | 13.1 | 0.3 | 8 | 0.702 (96) |
| French Polynesia              |        | UN | NA | NA | NA | NA | NA | NA | NA |
| Grenada                       |        | UN | X | 2.4 | 4.4 | 10.5 | NA | 38 | 0.770 (63) |
| Guadeloupe                    |        | N  | NA | NA | NA | NA | NA | NA | NA |
| Guam                          |        | N  | NA | NA | NA | NA | NA | NA | NA |
| Guinea-Bissau                 |        | UN | X | 0.2 | 1.4 | 5.7 | 0.6 | 1 | 0.364 (176) |
| Guyana                        |        | UN | X | 2.0 | -0.2 | 3.8 | 0.7 | 4 | 0.636 (118) |
| Haiti                         |        | UN | X | 0.3 | 1.7 | 9.4 | 8.6 | 65 | 0.456 (161) |
| Jamaica                       |        | UN | X | 4.5 | 1.4 | 15.2 | 6.2 | 3 | 0.370 (85) |
| Kiribati                      |        | UN | X | 0.3 | -1.0 | 12.4 | NA | 0 | 0.629 (121) |
| Maldives                      |        | UN | X | 3.0 | NA | 9.1 | 15.7 | 0 | 0.688 (104) |
| Marshall Islands              |        | UN | X | 1.9 | NA | 11.0 | NA | NA | NA |
| Martinique                    |        | N  | NA | NA | NA | NA | NA | NA | NA |
| Mauritius                     |        | UN | X | 3.1 | 4.4 | 15.2 | 26.4 | 1 | 0.737 (80) |
| Montserrat                    |        | N  | NA | NA | NA | NA | NA | NA | NA |
| Nauru                         |        | UN | X | 3.9 | NA | 12.1 | NA | NA | NA |
| New Caledonia                 |        | N  | NA | NA | NA | NA | NA | NA | NA |
| Niue                          |        | N  | NA | NA | NA | NA | NA | NA | NA |
| Palau                         |        | UN | X | 10.5 | -0.3 | 11.4 | NA | NA | 0.791 (52) |
| Papua New Guinea              |        | UN | X | 0.3 | 0.3 | 11.4 | 0.0 | 4 | 0.466 (156) |
| Puerto Rico                   |        | N  | NA | NA | NA | NA | NA | NA | NA |
| Samoa                         |        | UN | X | 0.9 | 3.9 | 10.8 | NA | 5 | 0.702 (96) |
| São Tome and Principe         |        | UN | X | 0.8 | 3.7 | 14.9 | 0.3 | NA | 0.525 (144) |
| Seychelles                    |        | UN | X | 7.8 | 7.3 | 16.1 | NA | 0 | 0.806 (46) |
| Singapore                     |        | UN | NA | 6.7 | -0.7 | 13.7 | 31.7 | NA | 0.895 (18) |

(Continued)
### Table 3.1 (Continued)

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**Notes:**
2 Least Developed Country category according to UNCTAD (2012).
3 Above average environmental vulnerability on UNEP environmental vulnerability index compared with average for all LDCs (UN DESA 2010). The Environmental Vulnerability Index is based on 50 indicators covering natural/anthropogenic risks, resilience and ecosystem integrity, and covers issues related to climate change, biodiversity, water, agriculture and fisheries, human health, desertification, and exposure to natural disasters (UN DESA 2010).
4 Anthropogenic carbon dioxide emissions stemming from the burning of fossil fuels, gas flaring and the production of cement, including carbon dioxide emitted by forest biomass through depletion of forest areas; divided by midyear population (UNDP 2013). Figure does not include non-CO2 greenhouse gas emissions. World Bank (2012) in UNDP (2013).
7 Total freshwater withdrawn in a given year, expressed as a percentage of total renewable water resources. FAO (2011) in UNDP (2013).
8 Number of people confirmed as dead and missing and presumed dead as a result of a natural disaster. Natural disasters are classified as climatological, hydrological and meteorological disasters, which include drought, extreme temperature, flood, mass movement, wet storm and wildfire. UNDP (2013) using United Nations Department of Economic and Social Affairs and Centre for Research on the Epidemiology of Disasters data.
9 The Human Development Index (HDI) is a composite index measuring average achievement in three basic dimensions of human development—a long and healthy life, knowledge and a decent standard of living (UNDP 2013).
10 Figures from UNDP (2013)
saline intrusion, and the intersection of groundwater with the surface, all of which can lead to inundation of low-lying areas (Nunn 2013).

Rapid urbanisation and environmental degradation can also lead to the loss of coastal forests, mangroves, and coral reefs that act to cushion the impacts of storm events. However, the implications of climate change are not isolated to sea level rise and problems for SIDS are magnified by forecast increases in the intensity of weather events (Mimura et al. 2007; IPCC 2013), as well as, in some cases, damage to surrounding coral reefs that serve to reduce wave impact and tidal surges as a result of coral bleaching events and ocean acidification (Forbes et al. 2013). According to the Alliance of Small Island States’ (AOSIS) Declaration on Climate Change, ‘climate change poses the most serious threat to our survival and viability, and . . . undermines our efforts to achieve sustainable development goals and threatens our very existence’ (AOSIS 2009: 1). As is the case with many developing countries the majority of SIDS are low contributors to greenhouse gas emissions on a per capita basis (Table 3.1), yet bear the brunt of many of the effects of climate change.

Climate change has exacerbated weather-related natural disasters, and cyclones, floods, and droughts have increased in frequency and intensity since the 1960s (Scott et al. 2012). The capacity of SIDS to adapt to climate change is affected by their overall level and rate of economic development, and possibly distribution of wealth, as well as their propensity to be affected by sea level rise and significant climate variability in the form of severe weather events. The IPCC (2014) notes that barriers to adaptation strategies in island settings include ‘inadequate access to financial, technological and human resources, issues related to cultural and social acceptability of measures, constraints imposed by the existing political and legal framework’, and significantly given the focus of the present volume, an ‘emphasis on island development as opposed to sustainability’ (ibid.: 27). Nevertheless, despite the media profile often given to climate change and SIDS, there is still substantial lack of understanding and awareness on many islands with respect to climate change (Nunn 2009). This may be further complicated by the failure of adaptation and vulnerability communication and planning strategies to address the role of traditional belief systems of island inhabitants (Mortreux and Barnett 2009). Even where problems are recognised, continuing community preferences for ‘hard’ adaptation measures such as seawalls instead of ‘soft’ measures such as beach nourishment (IPCC 2014) also suggest a failure to adequately communicate climate change adaptation measures and their long-term effectiveness and implications (Hall 2014).

Because of their small size and disproportionate share of population living in hazard prone coastal areas SIDS are particularly vulnerable to natural disasters. Samoa, Saint Lucia, Grenada, Vanuatu, Tonga and Maldives are among the top 12 countries with the highest economic losses on capital stock in relative terms due to natural disasters from 1970 to 2006 (Baritto 2009). In the case of Samoa, due to the relatively small size of its economy, the damage caused by a tropical storm and a forest fire in 1983 as well as three tropical storms in a row from 1989 to 1990, may have led to the destruction of its capital stock equivalent to a reverse of more than 35 years (ibid.). It is also important to recognise that hydro-meteorological disasters are significant not only because of their direct effects on infrastructure and economic and population well-being but also because they can affect investor and tourist perceptions (Scott et al. 2012). The latter is especially important because of the disproportionate economic importance of tourism in SIDS compared to other countries (Gössling et al. 2009).

The combination of population increase, urbanisation and environmental change is also placing pressure on SIDS’ water supplies with the amount of available renewable freshwater in decline in the majority of island states in the Caribbean and the Pacific (World Bank 2012). Sea level rise, surges and flooding can lead to saltwater intrusion into freshwater aquifers
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(Chui and Terry 2013), with the water supply also being affected by the groundwater contamination and over-extraction associated with urbanisation, population growth, and industrial demands. Some countries comprised of groups of low-lying small islands, such as Barbados, Kiribati, and Tuvalu, have chronically limited freshwater resources, low annual rainfall, and shallow water tables (UN DESA 2010), which have necessitated shipping of water to some islands at times of drought as well as the purchase of desalination plants.

Because of the nature of islands, coastal and marine resources invariably tend to be economically as well as ecologically important. Yet they are also among the resources most susceptible to global change. SIDS’ fish stocks are coming under increasing pressure (Allison et al. 2009), with potentially substantial implications for economic and environmental well-being (Ghina 2003; Kerr 2005). For example, in the Pacific, tuna fisheries make up more than 10 per cent of GDP and over 50 per cent of exports in some SIDS, and subsistence fishing supplies between 50 and 90 per cent of the animal protein diet for people in rural areas and remote islands (UN DESA 2010).

The decline of fish stocks mirrors a broader problem of indigenous species loss in island states. Islands are often important centres of biodiversity as their relative isolation contributes to high degrees of endemism as a result of speciation and the presence of flora and fauna that otherwise may have become extinct elsewhere. The relative isolation of many islands that are now part of SIDS that may have protected them from human activities or the introduction of predators for thousands of years unfortunately was lost in many cases first due to colonial mercantile expansion. Features of contemporary globalisation including the growth of international trade and tourism combined with faster modes of transport and liberalised economies only further encouraged the biotic movement that, together with urbanisation, land-use change and population growth, have provided the basis for the enormous loss of indigenous biodiversity in many islands.

Information on changes over time in the number of threatened species is only available for a limited number of categories of animals (birds, mammals, and amphibians) and plants for most small island countries. Taking these limitations into account, however, it is still apparent that the number of threatened species continues to increase (Hall 2010b). In the Caribbean, the number of threatened animal species as a proportion of all animal species in a given country ranges from a low of 6.6 per cent in Trinidad and Tobago to a high of 18.1 per cent in Bermuda. The proportion of threatened animal species is generally much higher in the Pacific Islands, and ranges from a low of 14.8 per cent in Tonga to 22.4 per cent in French Polynesia (ibid.).

Studies of species-to-area relationships suggest that between 30 per cent and 50 per cent of a given community or ecosystem type needs to be conserved in order to maintain between 80 per cent and 90 per cent of species (Groves 2003). Yet only two Caribbean island states (the Cayman Islands, and Trinidad and Tobago) and one in the Pacific, Kiribati, have designated more than 30 per cent of their landmass as nature protection (Hall 2010b). These figures only refer to the overall area being conserved and not the proportion of specific ecosystems that are set aside. Island ecosystems that are suitable for conversion to agriculture are the most underrepresented areas in conservation strategies. Furthermore, despite the economic and environmental importance of marine resources – especially fish stocks – the proportion of marine area in the Caribbean and Oceania that is protected is much lower than that for terrestrial areas. In the Caribbean, Jamaica has the highest proportion of marine area set aside (3.56 per cent), while in the Pacific, Palau has protected 8.74 per cent of its marine territory (Hall 2010b).

This overview of SIDS highlights why their vulnerability and resilience are of significance to understanding broader issues of sustainable development and the capacity for social and economic development without running down natural capital. Kerr (2005) suggests that models of
sustainable development grounded in constant stock approaches, i.e. if one generation bequeaths to the next a stock of resources equivalent to that which it has inherited, and the development of sustainable decision-making practices, may have something to offer islands in terms of the management of resources. However, islands have ‘very limited control over exogenous threats or the economic drivers of development’ (Kerr 2005: 519). While Kerr’s observation may be supported by the contemporary situation of many SIDS, it raises broader questions about the extent to which islands of sustainability can ever be established within a sea of global change. Given the exigency of global environmental change and a globalised economy that emphasises the permeability of borders, at least for trade, capital, the highly skilled and wealthy, are the problems of sustainable development for islands and SIDS to be regarded as a special case or do they represent the problems of sustainable development writ small?

Islands and sustainable development: an island biogeographical approach

Islands have played a key role in the development of ecological thinking, perhaps most famously with respect to the development of evolutionary thought but also with respect to the theory of island biogeography (Quammen 1996). The concept of island biogeography examines the relationships between species and a given area (MacArthur and Wilson 1963, 1967) and is therefore especially significant for conservation science. The conventional expression of the species–area relationship is $S = CA^z$ where $S$ and $A$ are species count and area, respectively, and $C$ and $z$ are fitted species specific constants. However, significantly for the wider applicability of the species–area relationship, an ‘island’ can be regarded as any area of suitable habitat that is surrounded by unsuitable habitat. This therefore includes not only terrestrial islands but can also be any appropriate bounded space.

The number of species that are found on an island depends on several factors, including its area and topography, habitat diversity, shape, spatial and temporal isolation, climate, previous connection to landmasses, accessibility to its source of colonists (i.e. not just distance to nearest source region but location relative to ocean and wind currents), and the equilibrium rate of colonisation by new species and the rate of extinction of existing species (Cox et al. 1973). The equilibrium model of the biota of a single island proposes that the equilibrial species number is reached at the intersection between the curve of the rate of new species immigration, not already on the island, and the curve of extinction of species on the island (Figure 3.1). The model therefore suggests that although fluctuations will occur over time there is a finite limit on the species biodiversity of a given area. This is highly significant in biodiversity conservation terms as, because every species runs the risk of extinction, ‘the more that have arrived, the more species there are at risk. In addition, as more species arrive, the average population size of each will diminish as competition increases’ (Cox et al. 1973: 98).

MacArthur and Wilson favoured logarithmic transformations of both axes thereby enabling the constants $c$ and $z$ to be determined by least squares (linear) regression (Whittaker and Fernández-Palacios 2007). MacArthur and Wilson (1967) found that in most cases $z$ falls between 0.20 and 0.35 for islands. The model is highly significant in that, even though it has substantial heuristic value without it, the contribution of the theory to biogeography and environmental conservation provides a high degree of rigour with respect to dynamic modeling of ecological population processes.

Island biogeography has been extensively applied to studies of the suitability of habitats and ecosystems for conservation purposes (Whittaker and Fernández-Palacios 2007; Ford 2011; Hanski 2011; Van Teeffelen et al. 2012; Heinken and Weber 2013). However, while there is recognition of its relationship to the human appropriation of net primary production/natural
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Figure 3.1  Equilibrium model of the single island biota. The equilibrial species number is reached at the intersection between the curves of the rate of immigration of new species, not already on the island, and the curve of extinction of species on the island. Immigration rates are postulated to vary as a function of distance, and extinction rate as a function of island area (increased competition for finite natural resources). The model predicts different values for $S$ (number of species), which can be read off the ordinate and for turnover rate ($T$) (the number of species that become extinct and are replaced by immigrants and speciation over unit time). Each combination of island area and isolation should produce a different and unique combination of $S$ and $T$. For reasons of uncluttered illustration only limited values are shown. The equilibrium point at which $I$ equals $E$ is never completely constant as it will shift over time in relation to a range in external and internal factors however the key point is that there is a ‘capacity’ to how many species can successfully inhabit a finite area over time (Whittaker and Fernández-Palacios 2007; Hall 2010b).

Figure 3.2  islands provide an opportunity to provide a boundary to study competition between human consumption and wildlife for natural capital (Figure 3.2) (Czech 2004). With such competition, of course, being one of the major reasons why many island ecosystems have suffered such a high degree of loss of endemic biodiversity as a result of habitat loss and land use change. Figure 3.3 illustrates the interconnectedness of human economic systems and natural systems in more detail, with the central box showing the interrelationships between human and ecological systems in an island as well as inputs and outputs in terms of energy and waste as well as the capital as an environmental indicator of sustainable development (Haberl 1997, 2006) and ecological footprinting (Haberl et al. 2004; Galli et al. 2012), some of the practical and theoretical implications of theories of island biogeography for economic dimensions of sustainable development have perhaps not been fully explored despite islands being sites of theoretical novelty (Baldacchino 2007). This is even more surprising given the awareness of issues of resilience and vulnerability for island species and ecosystems that arise from island biogeographical research (Marzluff 2005; Levin and Lubchenco 2008).
circulation of capital, people and species. Following industrial ecological thinking (Korhonen 2005), the human or industrial system is reflected as an analogue of the natural system. However, given the finite nature of natural capital, the human system will often grow at the expense of the natural capital stocks available in the natural system at a rate faster than it can be renewed—what is otherwise described as unsustainable development. Such 'drawdowns' of natural capital as a result of human disturbance and extraction can lead to substantial perturbations of natural systems leading to species extinctions. This process is especially pronounced on islands.

Nevertheless, islands are inherently dynamic (Lomolino 2000a; 2000b). A more accurate assessment is therefore provided in Figure 3.4 which presents a tripartite model of island biogeography with respect to the three fundamental biogeographic processes of immigration, extinction and evolution as a function of island characteristics of area and isolation. Under Lomolino's (2000a) approach immigration rates should increase with proximity to a source region and the ability of species to travel or transported across immigration barriers and filters. Extinction rates should decrease as island area increases, or increase with growing resource requirements of the focal species. Finally, speciation should be most important where extinction and immigration are lowest and therefore it increases in relation to increase in island area and isolation and decreases with respect to resource requirements and the capacity of species to move or disperse within their environments (Lomolino 2000a). The model, especially when considered in conjunction with figure 3.3, also suggests the importance of both the independent and interacting affects of anthropogenic stressors on natural capital, e.g. climate change, habitat loss, over-exploitation and the introduction of exotic species (Mora and Zapata 2013). However, just as significantly, the interrelationships between island characteristics and biogeographical processes provide for the relative resilience of islands to disturbance, whether from storms or drought, or from direct anthropogenic pressures (Hall 2010b; Jackson and Sax 2010; Yackulic et al. 2011).

Island biogeography clearly provides a means to help explain and analyse island conservation issues. However, the application of the island biogeography approach to sustainable development of islands also provides a clear analogue to the human and economic ecology of islands as well.

\[\text{TIME}\]

\[\text{GDP}\]

\[\text{Natural capital allocated to wildlife}\]

\[\text{Natural capital allocated to the human economy}\]
Figure 3.5 presents a model of the application of island biogeographical theory to the understanding of adaptation, resilience, and vulnerability of island economies. From this approach, the equilibrial or steady state number of businesses is reached at the intersection of the rate of immigration of new firms and capital, and the emigration or closure (extinction) of businesses on the island, along with the capacity of businesses to innovate and adapt (which is analogous to species evolution over time and the occupation of new ecological niches). Immigration rates are postulated to vary as a function of distance (which may be economic, cultural or perceptual rather than Euclidean), and closure rate as a function of island area and resources that determine the competition for finite natural and human capital. Although heuristic, the model can potentially predict different values for S (e.g. number of firms and/or capital) (in substituting values for Figure 3.1), and for turnover rate (T) (the number of firms that close and are replaced by immigrants and innovation over unit time). Each combination of island area and isolation should produce a different and unique combination of S and T. The equilibrium point at which I equals E is, of course, never completely constant as it will shift over time in relation to a range in external and internal factors however the key point is that there is a 'capacity' to how many businesses – or people, including visitors – can successfully inhabit a finite area over time without there being loss of natural capital.
Figure 3.4 Relationships between biogeographical processes and island characteristics

Source: Adapted from Lomolino (2000a; 2000b); Hall (2010b; 2012).
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Figure 3.5 Island biogeographical perspectives on island adaptation, resilience, vulnerability and sustainability

Source: After Hall (2010b, 2012).

Community characteristics of labelled regions are as follows:
A: Moderate to high economic richness, low endemicity and low turnover (e.g. Singapore);
B: Moderate to high economic richness, high endemicity and low turnover (e.g. Cuba);
C: Moderate to low economic richness, low endemicity and high turnover (e.g. Bahamas);
D: Low economic richness, low endemicity and high turnover – a depauperate island economy (e.g. Nauru).

Economic richness is the number and variety of different businesses.
Endemicity is the number of businesses unique to the island/location. It does not include international chains.
Immigration refers to the inflow of firms, people and/or funds.
Extinction refers to firms ceasing to operate.
(Hall 2010b) and without there being substantial importing of external resources, e.g. energy, food, water and/or economic capital, to maintain a given population base.

Anthropogenic impacts on islands provide clear illustrations of the environmental pressures on island resources, which can only be satisfied by importing resources from elsewhere unless such resources are either going to be depleted and/or limits are placed on the number of resource users. This is evidenced, for example, in the import of food and water to many island tourism destinations to supplement what cannot be provided locally in order to meet a given level of real population demand (real population is the permanent population plus the temporary tourist population at any given time) (Hall 2010b; Gössling et al. 2012). In such situations if land resources are available, it may be possible to develop higher degrees of economic endemism so as to reduce external resource inputs. However, in many SIDS this will not be possible given their extremely limited area.

Using an island biogeographic approach to examine issues of sustainable island development and hence the notion of islands of sustainability clearly raises substantial questions as to whether this is possible or not. It may be the case that islands that are located close to mainland areas in the developed regions of the world with ample resources and relatively low population levels may have the potential to develop dense self-sustaining network economies within existing resource and human capacities, but for many SIDS it is a highly doubtful prospect. As with many of the animal species on islands, many businesses occupy a specialised niche in order to survive. The limited resource base of most islands means that if a relative advantage exists, it only does so in a small number of sectors, usually fisheries, tourism, financial services, and traded agricultural products (Kerr 2005). However, such specialisation not only leads to lack of diversity in the business base but also makes the economy extremely vulnerable to external economic and environmental change and even more dependent on remittances and aid payments (Pelling and Uitto 2001; McGillivray et al. 2010).

Conclusion: islands – an analogue of what?

Much of the focus of the sustainable development of islands has been on climate change with respect to the threats of sea level rise and increased high magnitude weather events. Undoubtedly, such threats are extremely important. But as this chapter has suggested, the threats to SIDS are much wider and lie in the synergistic nature of global change factors as well as the inherent characteristics of islands themselves. Yet, SIDS remain committed to a growth economy instead of one focused on development.

There is very little to suggest in the data on SIDS that they illustrate the possibility of becoming islands of sustainability, defined in terms of ‘a constant flow of throughput at a sustainable (low) level, with population and capital stock free to adjust to whatever size can be maintained by the constant throughput beginning with depletion and ending with pollution’ (Daly 2008: 3). Population pressures are often being reduced by emigration that also provides a means to return economic capital to the SID via remittances. Some economists have argued that this is a logical approach to maintaining material welfare in island states (Bertram 1993). However, remittances and aid are dependent on economic growth in metropolitan areas and sympathetic policy settings with respect to migration and aid. The degree of specialisation in island economies is highly vulnerable to competition as well as changes in demand and accessibility. Undoubtedly, many SIDS are also seeking to innovate through community-based projects as well as via new business initiatives often as part of aid programmes but the long-term economic prospects remain bleak especially as many individuals continue to be attracted by employment elsewhere.
The combination of social and economic factors means that the capacity of the majority of SIDS to undertake effective environmental and climate change adaptation measures are constrained by a short-term policy focus and limited budgets. Such a situation affects the urgent need of many SIDS to mainstream or integrate climate change adaptation and sustainable planning strategies into development plans and policies (IPCC 2014; Swart and Raes 2007), a situation that is only exacerbated by the often failure to effectively communicate climate change information to island peoples with traditional belief and decision-making systems (Nunn et al. 2014).

It can be argued of course that even within SIDS there may be small-scale islands of sustainability that seek to create the transitions required for sustainable development. Perhaps. But the fact that they are slow in coming and the enormous difficulties facing SIDS provides a mirror to the problem of sustainable development writ large. For many islands, carrying capacity is being maintained artificially high by inflows of capital, often via aid and remittances, often to fund food, energy and even water supplies that cannot be provided locally and/or by people emigration. Endemic innovation is important in using indigenous resources more efficiently, but is not by itself sufficient to maintain levels of natural capital. Such a situation is a good metaphor for sustainability, but at a global scale. The lesson of island biogeography is that, given with current technologies the potential to emigrate to a long-term survivable environment elsewhere in the solar system being slim, we instead face the prospect of extinction for many species, and ongoing anthropogenic transformation of natural capital.

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