Mining, land restoration and sustainable development in isolated islands: An industrial ecology perspective on extractive transitions on Nauru

Martin J. Clifford, Saleem H. Ali, Kazuyo Matsubae

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Abstract In this empirically grounded perspective, we explore how, if managed correctly, mining might go beyond a straight conversion of finite natural capital to financial resources. We suggest a process where mineral extraction could act as a catalyst for more diversified growth and even serve as a basis to restore forms of ‘natural capital’ it had previously diminished. The case in point—small in scale but significant in consequence—is the particularly challenging instance of the small-island state of Nauru, which has a very negative history of socio-ecological impacts of phosphate mining. Yet, the degraded landscape requires capital investment which could be reaped from restoration of the land using revenues generated from exporting the waste rock pinnacles as branded household counter-tops and pavement stone products with an “island provenance premium”. Furthermore, we use an industrial ecology method to show that Nauru’s secondary phosphate can be shown to be less environmentally impactful than comparable phosphate from other sources. This has potential for further “green branding” of the Island’s products. We contend that implementing such a restoration approach that harnesses the remaining mineral capital with care has the potential, to diversify the island’s economy from one dependent on extractive industries and donors to agroforestry, fishing and tourism. A holistic approach is offered that considers prudent use of Nauru’s remaining mineral resources towards an agenda of ecological restoration and economic diversification that will allow the island to prosper after the phosphates it has traditionally relied upon are depleted.

Keywords Industrial ecology · Mining · Nauru · Phosphates · Rehabilitation · Sustainable development

INTRODUCTION

In an era of progressively urgent debates surrounding climatic change, sustainable development and natural resource efficiency, the future coping ability of small-island nations is particularly concerning: they are most vulnerable to extreme weather events, sea-level rise, geographically isolated; typically have relatively undiversified economies, minimal natural resources and are reliant upon external inputs and assistance (Hanna 2013; Scandurra et al. 2018).

Such factors are already beginning to impact island states, with earlier speculation over the possibility of ‘environmental refugees’ (Walker 2004; Westra 2009; Dreher and Voyer 2015) in the Pacific region becoming an increasing reality (Doherty and Roy 2017). The numerous issues facing island nations have also resulted in growing international attention: the United Nations declared 2014 the year of the Small-Island Developing States (SIDS) and the conception of the SIDS Accelerated Modalities of Action (SAMOA) pathway affirm their need for concerted sustainable development efforts.

While SIDS Face common threats, their coping capacity is heterogeneous. Some have been successful in niche sectors like banking and tourism (e.g. the Caymans, various Caribbean islands), which have provided significant developmental benefit comparative to the size of their populations and constitute relatively sustainable income streams in parallel with low environmental impacts. In contrast, others, particularly those based on exploitation of

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limited natural resources or primary commodities, have found sustained socioeconomic development much harder to achieve, and often at large environmental expense. Nauru, the island that forms the focus of this paper, is one classic case of this, displaying a ‘boom to bust’ trajectory that leaves its viability in the balance.

The island state of Nauru is strategically located in the Central Pacific and was at the crossroads of many colonial ventures, including the Germans, the Japanese and the British, and its indigenous population was almost exterminated in the early twentieth century. Colonial strife and an influenza epidemic bought the population down to 200 at the turn of the twentieth century but the resilient Nauruans bounced back and now more than 11 000 inhabit the island. The island’s location close to the equator keeps it away from typhoon paths and its topography has an unusual plateau region for most of the island’s expanse that makes it also more resilient to sea-level rise than other island states (Fig. 1; Table 1).

Despite its geographic advantages, Nauru has a long yet unfortunate association with mining. The small island¹ was abundantly rich in phosphate deposits (Jacobson et al. 2004) and intensively mined during the early twentieth century by various colonial overseers seeking to profit from surging demand for phosphorus-based agricultural fertilisers (Reijnders 2014; Ashley et al. 2011). While benefitting very little from mining under foreign control, expectations following Nauruan independence (in 1969) that the significant remaining reserves provided an enviable basis for successful development (Connell 2006) initially proved true: phosphates made Nauru one of the world’s richest countries per capita during the 1970s, allowing the establishment of a welfare state, substantial royalty payments amongst the population and foundation of a trust fund for future generations.

Unfortunately, this trajectory was fleeting and Nauru is now often cited as a parable of economic and ecological distress (McDaniel and Gowdy 2000). Revenues were mismanaged and political instability has been a consistent feature, leaving the country deeply indebted, heavily reliant on aid and little contemporary evidence of its former wealth. 80% of Nauru has been mined for phosphate, leaving pinnacles of limestone that occur alongside phosphate rock, making this land unusable (Fig. 2).² The only potentially tenable land remains around the densely populated coastal fringes. Yet agricultural land and production was forfeited during the ‘boom years’ in favour of

imported goods, on which it is now largely dependent.³ Mining has also damaged surrounding aquatic habitats (Vuinesa et al. 2008; cited in Butusov and Jernelöv 2013; Trujillo et al. 2017) and continues to represent an overall risk to Nauru’s human and ecological health (Government of the Republic of Nauru 2013).

Nauru’s decline was such that Connell (2006) speculated that it represented the Pacific’s first ‘failed state’ and Pollock (2014) tied in ‘resource curse’ narratives in an analysis of the island. Even the government suggests that ‘with severe constraints in resources on land and sea... Nauruans will have no other recourse but to rely heavily on outside assistance and the exploitation of their remaining natural assets’ (Government of the Republic of Nauru 2014b, p. 31). Indeed, the length of this article cannot do justice to the multitude of interrelated ways that historical and contemporary mining has deeply affected the island.

Nauru has not ‘failed’ quite yet but is increasingly short of options. Aid payments (totalling over US\$16.5 million in 2016–2017) and revenues for hosting ‘Regional Processing Centres’ for the Australian government (currently 40% of GDP) are ‘clouded in uncertainty surrounding a potential winding down’ (ADB 2017, p. 292). The reliance upon issuing of international fishing licenses in their waters (30% of GDP), rather than directly utilising this resource, is also arguably not a reliable basis for national income. Perhaps most significantly, phosphate reserves, the mining of which resumed in 2005 following a 2-year hiatus and constituted 63% of exports in 2015 (OEC 2017) are estimated to be exhausted in 30 years (Gale 2016) and much prove less profitable than before (Crowley 2011; Reijnders 2014).

There is, therefore, a clear need to identify pathways towards a more sustainable future Nauruan economy, society and environment. This discussion takes the pragmatic view that, given the longstanding centrality of the resource to the island and that it is perhaps the best/only choice out of a set of ‘bad’ current options, phosphate mining is likely to form the mainstay of the Nauruan economy while reserves remain. The theme here, however, is to analyse how ‘smart mining’ of natural resources might stimulate financial diversity and build natural capital to allow Nauru to be sustainable in its ‘post-phosphate era’.

In fact, what we suggest is that, paradoxically, a more sustainable future on Nauru must almost certainly begin with further mining on the island: the environmental

¹ Along with other geologically similar islands formed from coral atolls like Banaba and Makatea.

² An excellent digital image of the island, showing environmental damage, is available at <https://ejatlas.org/conflict/phosphate-mining-on-nauru>.

³ In fact, Nauru imports almost all its commodities at considerable expense. For example, being dependent on generators for electricity, petroleum made up a startling 36% of imports in 2015 at a cost of US\$26.1 million. This is in addition to almost a million dollars’ worth of water and food (OEC 2017).

Fig. 1 Location and basic map of Nauru. *Source* Pinterest; *Source* Wiki Commons

destruction is such that removal of remaining phosphate and surrounding limestone (Figs. 2, 3, 4) is a necessary first step in repairing the island. And, indeed, if conducted in a responsible manner, the activity can ultimately result in an improved rather than weakened set of ‘ecological goods and services’. We outline our case by suggesting three phases of a hypothetical process of rehabilitation for the

island. These tie explicitly into the self-defined priorities of the Nauruan government’s National Sustainable Development Strategy (Nauru Government 2009), which emphasises building ‘an economy based on multiple sources of revenue’, ‘rehabilitation of mined-out lands’ and ‘domestic food production’.

Table 1 Selected indicators for Nauru. *Sources* World Bank, CIA Factbook, UNdata, OEC

Indicators	Value	Year
Population	11 359 (2016)	2016
Land mass	21 km ²	N/A
GDP (PPP US\$)	151 000 000	2016
GDP per capita (PPP US\$)	11 600	2016
GDP growth rate	– 4.0% (2018 est.) from 4.0% (2017)	N/A
Economic composition (% of GVA)	Agriculture: 3.2% Industry: 58.2% Services and other: 38.6%	2014
Exports	Calcium Phosphates: 63% Scrap Vessels: 19%	2015
Imports	Petroleum: 36% Prefabricated buildings: 7.3% Vehicles: 6.3% Food and water products: 10–11%	2015
Human Development Index	164/193	2009

MINING AS A SPRINGBOARD

Given the inability to use most of the island's land for productive use due to incomplete mining land on the plateau part of the island excavation of remaining phosphates and limestone pinnacles is a logical, if not requisite, starting point for the ecological rehabilitation of Nauru (Fig. 3). Indeed, all appropriate sources (Thaman and Hassall 1998; Crowley et al. 2010; Davis 2010) agree that the post-mining phase should begin by levelling out land through quarrying of the pinnacle rock for mining and backfilling of pits (Fig. 4). Two subsequent uses of land are suggested. The first is residential, deemed important in the context of climatic change with the island's interior being of higher elevation. Given Nauru's limited productive capacity, however, the preferable, second option (and as targeted in the NSDS) would be to utilise the interior for ecological restoration and agricultural production.

Three phases are discussed below as a blueprint for undergoing this shift in land use from mineral to agricultural. Focus is maintained on attempting, where possible, to

Fig. 2 Limestone pinnacles following phosphate mining on Nauru. *Source* Photograph by Saleem H. Ali

Fig. 3 Primary and secondary phosphate mining. *Source* Thaman and Hassall (1998)

suggest the most productive and responsible fashion in which to proceed within each phase. It is also important to note that the phases could (and in fact almost certainly should) occur in a parallel rather than divergent fashion, that is, harvesting of limestone can begin as soon as phosphate mining is exhausted and ecological restoration can start as soon as limestone mining ends at different locations and points of time across the island.

Phase 1: Extracting remaining phosphate deposits

Assuming that operations run at a currently stated output of 600 000 tonnes a year (see Table 2)⁴ and last for the projected thirty years (it was estimated in 2005 that 40 years-worth remained), then—at current world prices—the country would earn US\$69 million gross a year over the 20 years, roughly equivalent to two-thirds of the island's

⁴ The numbers for phosphate production and quantities for waste by-products (pinnacle rock, crushed rock, reject phosphate, topsoil and compost) given in the results section below are taken from measured and projected figures provided to the authors by the Nauru Rehabilitation Corporation, which is responsible for mining of phosphate on the island.

current GDP per year. Therefore, phosphates are, as previously stated, likely to return to the forefront of Nauru's economy for a finite amount of time. However, removal of Nauru's remaining deposits is discussed here solely as an inevitable first step towards more sustainable trajectories, featuring associated 'waste' products (see Table 2) as a prominent constituent of forging new ecological and economic possibilities.

Phase 2: Effective utilisation of limestone rock

The reserves of limestone that occurs with Nauru's phosphates and form fields of pinnacle across most of the island's surface are unsurprisingly considerable, estimated at 90 million tonnes (NRC 2013) and 'can be readily quarried' in 'for practical purposes, unlimited' amounts (Davis 2010, p. 5). Again, and as shown in Fig. 4, land can be returned to a useable state once pinnacle rock is cleared, making this extractive process inseparable from the wider project of rehabilitation.

Currently, around 60 000 to 80 000 tonnes of both pinnacle and crushed rock is produced per year, giving a staggering amount of over 500 years of supply at this rate.

Fig. 4 Land levelling in preparation for rehabilitation. *Source* Thaman and Hassall (1998)

Limited commercial uses of limestone are already in place for building aggregates and ‘armour rock’ for coastal defences. The resource would also provide an almost unlimited on-site supply of construction material, avoiding significant import costs (Crowley 2011). Yet average yearly production would yield only US\$400 000 (at US\$5 a tonne), a fraction of current GDP. The pinnacles are high-quality limestone, however, suitable for a range of uses and likely to command a decent price within international markets (NRC 2013). Previous evaluations (Crowley et al. 2010) were pessimistic over Nauru exporting limestone anywhere other than its regional neighbours due to market competition. But Thaman and Hassall (1998, p. 78)

tentatively suggest that ‘with joint venture partners with technical expertise and market reach there is a limited scope for the marketing of polished stone, dolomite fluxes and aggregates’.

Far more financial benefit could be attained from processing the limestone in this way (Crowley et al. 2010; Davis 2010): paving slabs retail for approximately US\$5 per square meter (US\$7.3 per tonne), and kitchen counters for US\$600–800 per square meter (US\$881.25–1175 per tonne⁵), worth US\$587 700 and US\$70.5–94.0 million, respectively (at retail price) for total current production. However, despite a pilot stonecutting project on the island,

⁵ US\$400 is assumed in the TMP/TMR scenarios.

surprisingly little work has been done to establish economic feasibility and markets (Crowley et al. 2011).

An interesting avenue would be ‘territory of origin’ marketing, which has spread from traditional areas to include markets like stone products. If Nauru incrementally builds its capacity and showcases commitment to rehabilitating mined-out land, it could tie into the growing market for products that ‘generates associations linked to culture and tradition of a territory... as well as producers’ sincerity, honesty, morality and passion’ (Zhang and Merunka 2014). The associated island provenance premium⁶—justified in some respects by the TMR and TMP analyses displayed below—would allow Nauru to at least partially overcome the lack of competitiveness that has hampered this activity so far (Crowley 2011) and potentially provide a strong positive economic contribution from what has been seen for decades as an environmental burden.

TMR and TMP methods for assessing Nauru’s mineral management

An appropriate way to support our arguments above is using an industrial ecology approach that considers the relationship between industrial inputs such as phosphates and the environment from which they are derived from the perspective of an interconnected system. More specifically, we use part of a Materials Flow Analysis employed by industrial ecologists: a simplified version of which are Total Materials Required (TMR) and Total Materials Productivity (TMP) methods (Nakajima et al. 2006; OECD 2008), which have been applied to various energy resources and industrial materials (Halada et al. 2001).

TMR provides a basis for evaluating resource efficiency in terms of *mass* (Bringezu et al. 2003), providing a measure of both the physical inputs required to, and by-products resulting from, producing a material from a given resource using a given process. In many cases, TMR is an appropriately comprehensive indicator of resource intensity and environmental pressure because it includes not only direct and indirect material flows upstream of the process, but also hidden material flows, such as overburden and waste rock (Wuppertal Institute 2011).

The TMR for a given resource is defined as the sum of “direct material input” (DMI), “indirect material input” (IMI) and “hidden flows” (HF). TMR is calculated using the following equation:

$$\text{MTMR} = \sum \text{MDMI}(x) + \sum \text{MIMI}(x) + \sum \text{MHF}(x),$$

where MTMR indicates the mass of TMR to produce a substance ‘*x*’ (in this case phosphate rock), MDMI(*x*) the mass of DMI of substance *x*, MIMI(*x*) the mass of IMI of substance *x* and MHF(*x*) the mass of HF of substance *x*. Therefore, the lower the TMR to obtain a resource, the less environmentally and resource intensive one can say the processes involved are. A working example using data for Nauru is provided in [Electronic supplementary material](#).

A key element TMR in reference to our assessment of Nauru is that of ‘hidden flows’ or the ‘ecological rucksack’ (Schmidt-Bleek 1997). These are by-products of economic activities, which do not normally serve as inputs (“unused components”: Eurostat 2001). Overburden and waste from mining is a classic example of this. Thus, if normally ‘unused’ material from phosphate extraction is utilised, it is removed from the equation, the overall TMR and ‘ecological rucksack’ is reduced and resource efficiency accordingly improved. This is also used as a justification for branding Nauruan limestone as a “greener product” and whose extraction is helping a small-island developing state.

Building on this, Total Material Productivity (TMP) contrasts the amount of materials needed with the price obtained for the final product, that is, how (economically) productive the process is. This is done by dividing the profits obtained for the resource by the TMR to give a monetary figure per tonne. Usually, this is done on a national scale using GDP, but for our purposes we use pricing sets for individual materials in the results. 400 000 tonnes of phosphate sold for US\$90/tonne (\$36 million total) would give a TMP of US\$54.76/tonne. If the market price rose to US\$100/tonne, the TMP would also rise to US\$60.84/tonne accordingly.

Table 2 gives the results of a TMR and TMP analysis, which show the resource intensity and productivity associated with the mining of phosphates and limestone on Nauru. To illustrate the impact of the different possible trajectories, we adopt a matrix of scenarios that tie into our discussion relating to utilisation (how much material is used) and pricing (how much is obtained for each material).⁷ These scenarios are expanded upon in [Electronic supplementary material](#). A ‘post-phosphate’ scenario is also offered, wherein Nauru no longer produces phosphate rock but establishes a market for premium branded limestone products and continues a commitment to using the other by-products from mining in a productive manner.

As the preceding outlines of the TMR and TMP evaluations (and intuition) would dictate, Table 2 shows that as progressively more material is put to productive use and a better price is obtained for it, these indicators for resource

⁶ A mark-up of up to 30% has been suggested in a study by the University of Bonn (2015).

⁷ Note that topsoil and compost are not factored into the pricing scenarios, as these are valuable commodities for rehabilitation and not exported.

Table 2 Data and results of TMR and TMP calculations

TMR and TMP scenarios using Nauru's mining production, 2009–2014							
Year	2009	2010	2011	2012	2013	2014	
Phosphate output (tonnes)							
Phosphate rock production	400 000	550 000	600 000	600 000	600 000	600 000	
Materials produced as By-products (tonnes)							
Volume of pinnacle rock	110 895	66 380	88 638	88 637	70 910	47 273	
Volume of crushed rock	105 093	62 907	84 000	84 000	67 200	44 800	
Volume of reject phosphate	28 115	16 829	22 472	22 472	17 977	11 985	
Volume of topsoil	6881	4119	5500	5500	4400	2933	
Volume of compost	2971	1779	2375	2375	1900	1267	
Total volume	253 955	152 014	202 985	202 984	162 387	108 258	
Tonnes per month	21 163	12 668	16 915	16 915	13 532	9022	
Essential inputs (TMR added per tonne)							
Electricity and light diesel (combined)	0.0087						
TMR (TMR/tonne of phosphorus)							Average
1. 'Basic'—phosphate Mining alone	659 644	705 524	807 000	806 999	766 199	711 799	742 861
2. 'Current'—phosphate mining and crushed rock	553 637	644 667	725 240	725 239	701 235	669 230	669 875
3. 'Expanded'—phosphate, pinnacle and crushed rock combined	441 777	577 710	635 831	635 831	629 708	621 546	590 401
4. 'Ideal'—all resources except reject phosphates	431 840	571 760	627 888	627 888	623 353	617 309	583 340
TMP (US\$/tonne of phosphorus)—Baseline							Average
1. 'Basic'—phosphate Mining alone	54.57	70.16	66.91	66.91	70.48	75.86	67.48
2. 'Current'—phosphate mining and crushed rock	65.02	76.78	74.46	74.46	77.01	80.69	74.74
3. 'Expanded'—phosphate, pinnacle and crushed rock combined	81.49	85.68	84.93	84.93	85.75	86.88	84.94
TMP (US\$/tonne of phosphorus)—B.A.U							Average
1. 'Basic'—Phosphate Mining alone	54.57	70.16	66.91	66.91	70.48	75.86	67.48
2. 'Current'—phosphate mining and crushed rock	55.37	70.61	67.43	67.44	70.92	76.18	67.99
3. 'Expanded'—phosphate, pinnacle and crushed rock combined	83.93	86.80	86.29	86.29	86.85	87.62	86.30
TMP (US\$/tonne of phosphorus)—improved							Average
1. 'Basic'—Phosphate Mining alone	54.57	70.16	66.91	66.91	70.48	75.86	67.48
2. 'Current'—phosphate mining and crushed rock	66.92	77.76	75.62	75.62	77.97	81.36	75.87
3. 'Expanded'—phosphate, pinnacle and crushed rock combined	96.42	92.52	93.22	93.22	92.45	91.40	93.21
TMP (US\$/tonne of phosphorus)—value added							Average
1. 'Basic'—phosphate Mining alone	54.57	70.16	66.91	66.91	70.48	75.86	67.48
2. 'Current'—phosphate mining and crushed rock	66.92	77.76	75.62	75.62	77.97	81.36	75.87
3. 'Expanded'—phosphate, pinnacle and crushed rock combined	184.28	132.73	142.01	142.01	131.86	118.02	141.82
'Post-phosphate' TMP (US\$/tonne of material)—value added							Average
All limestone crushed	4.61	4.61	4.61	4.61	4.61	4.61	4.61
Pinnacle and crushed rock combined	177.26	177.26	177.27	177.26	177.27	177.26	177.26
Pricing sets							
	[\$/tonne]	Baseline	B.A.U.	Improved	Value Added		
P Rock		90.00	90.00	90.00	90.00		
Crushed		0.00	5.00	10.00	10.00		
Pinnacle		0.00	5.00	50.00	400.00		
Others		0.00	5.00	5.00	5.00		

efficiency improve. For the TMR utilisation scenarios alone, if all current 'waste' is used, then TMR drops from a 742 861 tonnes per year to 583 340 tonnes: over a 20% reduction. However, the largest increase comes from

bolstering the productivity (TMP): if Nauru can commercially utilise its limestone and gain a decent price for it, average TMP rises from US\$141.82 to US\$67.48/tonne of material that it would derive from phosphate mining alone.

The ‘post-phosphate’ projections are alarming and enticing in equal measure; could Nauru maintain the ‘adding of value’ to its limestone products, even to some degree, then productivity of its resources per tonne would actually *increase* in the absence of phosphates (up to US\$177 from US\$141 per tonne) reflecting the higher value per weight of extracted material; however, depending on lower value, limestone products would plunge the average productivity to under a tenth of that currently delivered.

Phase 3: ‘Sowing the seeds’—ecological rehabilitation, agriculture and proto-industries

Once mineral extraction is completed, what might ecological rehabilitation and future land use feasibly constitute on Nauru? Its geology, soil fertility and environmental conditions are challenging. Even undisturbed native soils are shallow, nitrogen-poor and lacking in moisture, nutrients, trace metals and organic content (Jackson and Manner 2005), which will remain even after basic rehabilitation. Water availability is another limiting factor. Nauru has very variable rainfall patterns and, owing to the geological permeability of the island, lacks any notable sources of standing fresh water. Groundwater is already used to maximum capacity, as are the islands ageing desalination plants, and drinking water is often imported.

Yet, if managed prudently, limitations to the rehabilitation and agricultural development that Nauru has identified as priorities would be navigable. In its favour, although it is unpredictable, Nauru does receive 2000 mm average annual rain rainfall (4000 mm in ‘wet’ years): easily enough to support agriculture. It is also protected from cyclones and has consistently warm and humid conditions. But, at present, domestic or larger-scale water retention technology on the island is poor. The Government of Nauru’s (2015) Water and Sanitation Master Plan highlights that significant investment will be required in water infrastructure but also raises some excellent ideas (including treated sewage sludge for agricultural use: see Zaman et al. 2002) that the country is more than capable of implementing. Encouragingly, both improved systems of simpler water capture and conservation methods (e.g. Burney et al. 2013) as well as advancements in hydro- and aquaponics⁸ are gaining legitimacy as agricultural methods in water-scarce environments (Goddek et al. 2015; Treftz and Omaye 2016), and could easily be trialled on Nauru. Advancements in the reintroduction of soil fertility to challenging and/or damaged environs are also providing successes. In a particularly salient example, Howieson et al. (2016) were able to dramatically improve soil

fertility and agricultural yields within just 5 years on rehabilitated phosphate-mining land on Christmas Island by introducing nitrogen-fixing plants and through appropriate selection of food crops.⁹

If improvements in both water capture and soil fertility prove successful on cleared lands, and existing information is accurate, Nauru could grow a range of produce. Thaman and Hassall (1998) suggest that a wide range of fruits, nuts and vegetables would all be suitable, preferably under a cooperative system of ‘integrated farming’, producing a range of outputs and recognised as being capable of maintaining soil fertility (Fa’anunu 2012). This includes typically higher-value tropical crops, like mangoes, guava and coconuts, that could command a decent price in regional markets like Australia, New Zealand and Japan. Even medicinal marijuana might be an outside option given the recent changes in Australian legislation.

In a similar vein to limestone, a reasonable avenue to explore are ‘ethically’ sourced products, under a ‘Fair Trade’ mark for which the consumer pays a small premium. They are also usually centred around small cooperatives, something seen as an ideal set-up for the island. This could be fresh goods but given the challenges involved with exporting fresh produce from Nauru’s isolated location, processed products may be advantageous. Clarke et al. (2011) and Fellows (2011) outline a variety of products that could realistically be produced with minimal expertise, expense and waste. Such relatively basic commodities do not offer huge profits but could represent a viable industry if run in a sensible, well-researched fashion. Positively, working case studies exist elsewhere: products made from coconuts, for example, have exponentially expanded. One family plantation in the Philippines supplies a range of coconut goods on the Australian market. And an ethically centred company, Kokonut Pacific, has assisted various island communities in the region establish small-scale coconut oil facilities that now ship internationally as Fair Trade.

DISCUSSION

The viability of the presented argument is conditional on many elements falling into place and is undoubtedly superficially controversial: advocating the continuation of mining in a locality that has historically suffered a great deal because of it appears questionable. Yet, upon taking as objective a view as possible at the options available to Nauru, the approach taken here is a mixture of practicality and optimism. Mining to extract the island’s remaining

⁸ The latter of these new techniques might be particularly appealing given the history of fish husbandry on the island.

⁹ Also see <http://www.abc.net.au/news/rural/2015-05-14/mintope-howieson/6466980> for an interview with the project manager.

phosphates has begun and is likely to continue for the next 30 years. How, then, can Nauru best prepare itself for beyond this point?

The obvious and immediate caveat to make and, indeed, something which the validity of the debate hinges upon, is that Nauru cannot afford to repeat its past profligacy with phosphates revenues. Fortunately, there are reasons to be hopeful on this front. Nauru has taken important steps towards improving its legitimacy and welcoming outside assistance, increasing engagement with multi- and bilateral organisations, consistently reducing its internal and external debts and committing towards public sector reforms aimed at strengthening its institutional capacity to drive through future changes (ADB 2014).

By far the most prominent example of this new phase is the establishment of a new, legally binding sovereign wealth fund, the Intergenerational Trust Fund for the People of the Republic of Nauru, shortened to Nature Trust Fund (NTF). As with the previous, ill-fated trust fund, the objective of the NTF is to save enough money (the principal target being US\$295 million) for the island to continue functioning after its remaining primary resources are exhausted. In this manifestation, however, the island's key bilateral donors and external parties will tightly oversee the ledger. No withdrawals are allowed in first 20 years of the fund's existence (i.e. until 2037) to allow for the pursuit of a 'growth-oriented investment strategy during the build-up phase' (Rajah 2017, p. 11). After this point, distribution of revenues from the fund will be made available for approved public spending that meets the NTF objective of securing a more sustainable future.

This timeline and remit fits very much into the spirit of this paper, with the central idea being that the improved economic and environmental capacity of Nauru will allow the country to engage in broader economic diversification following its mining period. We have outlined what we feel is an interesting and interconnected process of quarrying, land restoration and agricultural expansion for the island. Perhaps most pointedly, this route is one that can begin immediately; it fits with the island's identified sustainable development agenda; a new mechanism of oversight is there; the limestone is already there; the knowledge, techniques and technologies that can be experimented with and adapted towards rehabilitation are already there; the offer of outside expertise and resources are there and the outlined phases can occur concurrently over a period of time.

But this is only one of the many possible routes. For one alternative, as the FAO (2018) notes in its assessment of the country, there is no reason why Nauru might not adopt its traditions of aquaculture to offshore farms and take greater control over its fishing licenses. These activities would act as a buffer to fluctuations in other economic

sectors and provide another welcome source of local food production. As above, small-aquaculture and fisheries around Nauru could also be 'premium branded' for higher value. More controversially, there is also evidence that the country is beginning to explore the economic potential of its large exclusive economic zone and the surrounding Pacific region for the emerging sector of deep-sea mining, having signed laws in 2015 that established regulations over the activity following the state sponsorship of a deep-sea prospecting firm.¹⁰ However, in designating any profits into the NTF, environmental and socioeconomic impacts are likely to be closely monitored to ensure responsible spending.

Improving the island's infrastructure will be another key future consideration. Nauru currently imports all means to provide its energy (Government of the Republic of Nauru 2014a). Therefore, recent public-private funded solar projects¹¹ that have demonstrated solar power could represent a viable renewable energy source, with the restored 'topside' of the island containing plenty of space relative to the island's energy needs, are promising in terms of reducing the dependence upon imported petroleum for generators. Similarly, the proposed redevelopment of the dilapidated port would tie into the larger plan for making the island more economically and resource efficient.

CONCLUSION

Nauru's case is particularly striking given its 'boom to bust' trajectory and the unfortunate social and environmental legacy of phosphate mining. But, pragmatically, even if it had more prudently organised its mineral revenues, it would still eventually have had to face the reality confronting many small-island states in the region: limited sustainable natural resources, geographical and economic isolation and the looming threat of climatic change. This paper speculates on how Nauru might recover from its currently depressed state and reinvent itself for the future.

The wider prospects open to Nauru in pursuing more sustainable development are explored here. We do this through an admittedly utopian but considered appraisal of the available literature, mapping this onto a proposed pathway and attempting to augment our arguments by introducing measures for quantifying resource efficiency and productivity. In this perspective, mining on the island, a topic with an ill-fated past, is re-envisioned as a means to convert remaining, finite mineral resources into natural, social and financial capital that can provide viable, ongoing

¹⁰ <http://www.nauruoceanresources.com/>.

¹¹ <http://www.forumsec.org/resources/uploads/embeds/file/pec-fund-nauru.pdf> and Graves (2016).

alternatives. A key suggestion has been that mining—both of phosphates and surrounding limestone—almost *must* feature as an inaugural step in any developmental trajectory, being necessary in clearing scarred landscape so that it can be rehabilitated for any future use. We have attempted to identify how ‘clever mining’, featuring economic use of ‘waste’ materials, can ensure that Nauru turn this erstwhile burden into an asset, simultaneously reducing the island’s resource intensity (TMR) and improving productivity (TMP). Nauru’s former and current central activity cannot, then, be considered in isolation. It is argued that future development, despite being initially founded on extraction of its remaining mineral resources, can, if directed prudently, be a springboard for more sustainable activities.

In a broad sense, it should be noted that the proposed processes make no presumption of Nauru’s longer-term national socioeconomic outlook, be this ultimately part of the movement towards ‘rewilding’ or revitalisation of traditional livelihoods as advocated in Pacific academic and political discourses (Jørgensen 2015). Instead, rather than being prescriptive and ‘top-down’, we simply aim to tie in our approach to the stated aims of the country’s sustainable development strategy and consider its viability. Whatever ultimate form development takes on Nauru, the island cannot remain how it currently is, which is in itself entirely unsustainable. In a similar fashion, we see the environmental impacts of further mining (UNEP 2001) as acceptable given the points raised above and the sectors potential role in improving Nauru’s future prospects.

The Pacific islands have traditionally been relatively neglected due to their disparate nature and number. This is somewhat surprising, given that their small size would seemingly provide significant potential for achieving tangible development impact through donor assistance and selected economic strategies like preferential trade agreements and subsidies. Relocating Nauru’s entire population has been considered at more than one point. This has always been firmly rebuffed by a proud nation with strong historical and emotional links to the island. Indeed, as we have shown in this paper, Nauru’s small size can mean a fast rebound if there is a concerted effort at restoration and utilisation of natural capital for diversification of the economy through smart branding and commerce of its products. The same is true for many other SIDS grappling with global environmental change challenges.

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AUTHOR BIOGRAPHIES

Martin J. Clifford (✉) is a Postdoctoral Researcher in Energy and Environmental Policy at the University of Delaware. His work looks at a wide scope of aspects relating to mining, sustainability, transparency and corporate social responsibility in primary commodity industries, particularly the extractives sector.
Address: Department of Geography, University of Delaware, 220 Pearson Hall, Newark, DE 19716-2514, USA.
e-mail: martinjc@udel.edu

Saleem H. Ali is a Blue and Gold Distinguished Professor of Energy and the Environment at the University of Delaware. He is also a senior fellow at the Columbia Center on Sustainable Investment and a professorial research fellow at the University of Queensland. His work focuses on environmental conflict resolution and sustainable natural resource management.
Address: Department of Geography, University of Delaware, 220 Pearson Hall, Newark, DE 19716-2514, USA.
Address: Sustainable Minerals Institute, University of Queensland, Brisbane, Australia.
e-mail: saleem@udel.edu

Kazuyo Matsubae is an Associate Professor at the Graduate School of Engineering, Tohoku University, Japan. Specialising in analysis of sustainable material cycle, she has engaged the IO-based Material Flow Analysis and conducted several case studies of various nutrients including nitrogen and phosphorus and several metallic elements. Her current interest is in the identification of supply chain risks through resource consumption from a life-cycle perspective.
Address: Graduate School of Environmental Studies, Tohoku University, Sendai, Japan.
e-mail: matsubae@m.tohoku.ac.jp