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Deep sea mining's future effects on Fiji's tourism industry: A contingent behaviour study

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ABSTRACT

Pristine coral reefs possess a tremendous potential for contributing to tourism and economic development. This is especially important for Fiji given their tourism economy's reliance on diving and coastal activities. Understanding divers' perceptions of coral reefs and environmental issues is, therefore, paramount to sustaining the tourism industry. Despite the importance of coral reefs to the Fijian tourism sector, the Fijian Government has granted exploration licenses to mining companies to assess the viability of deep sea mining (DSM) activities in Fiji's seas. There is concern that DSM may negatively impact reef-related tourism due to tourists' perception that DSM activities degrades Fiji's coral reefs. This study conducts a contingent behaviour survey to explore how tourists' expectations of DSM will affect their future travel decisions and subsequently influence overall tourism demand in Fiji. Our findings show that divers and snorkelers demonstrate a high willingness to return to Fiji in the future, based on their previous travel experience, but that they would significantly reduce their future visits if DSM was to take place in Fiji. These results contribute to our understanding of the potential trade-offs between DSM and reef-related tourism and give some preliminary estimates of the potential economic consequences of the Fijian Government allowing DSM within their territorial waters.

1. Introduction

A tremendous potential exists for coral reefs to contribute to tourism revenue and economic development in developing countries. This potential, however, is subject to tourists' perceptions of the quality of the coral reefs in these locations [7]; Gonzalez et al. [22]; [39]. Among South Pacific Island Countries (SPICs), Fiji receives the highest number of visitors and is, in many respects, the most attractive tourism destination in the region [29,40,5,50]. The contribution of tourism to Fiji's economy is extensive, and it is estimated that tourism directly accounts for approximately 14% of Gross Domestic Product (GDP) and 12% of employment [9]. Fiji's coastal resources are a key attraction, with a substantial proportion of visitors undertaking activities such as snorkelling, diving, surfing and swimming [9,62].

Fiji's coastal resources, however, not only have potential tourism value, they also have potential value in terms of mineral resources. The deep ocean floor in many parts of the South Pacific is rich in valuable metals such as zinc, gold, copper and silver, and these metals could be extracted via a process known as deep sea mining (DSM). The Solwara 1 Project, managed by Canadian company Nautilus Minerals, is expected to be the first DSM activity in the Pacific, with extraction due to commence in 2019. Situated in the Bismarck Sea, approximately 30 km off the coast of Papua New Guinea's New Ireland Province, the Solwara 1 Project aims to recover high-grade polymetallic Seafloor Massive Sulphide (SMS) deposits that are located approximately 1600 m below the ocean surface [42,43].

In Fiji, the Government has issued exploration licenses for large areas of the ocean floor, although no DSM related activity has taken place to date [28,64]. There is concern that DSM could pose a potential threat to Fiji's coral reef and its surrounding environmental quality, and that this could have a devastating impact on reef-related tourism. If potential future tourists to Fiji believe that coral reefs in Fiji will be damaged from DSM activities, they may respond by altering their holiday destination choice. There is a significant gap in the tourism literature in terms of understanding how tourists' perceptions of environmental conditions affect their choice of holiday locations

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[20,21,24]. It is useful, therefore, to develop a better understanding of the factors that may affect tourists' destination choices in the face of changing (real or perceived) coral reef conditions. That is the primary purpose of this study.

Specifically, this study: (i) employs the contingent behaviour (CB) method to explore tourists' willingness to return to Fiji and its coral reefs, contingent on a hypothetical future scenario where DSM is (and is not) taking place in the seas around Fiji's islands; and (ii) investigates the broader economic impact of any hypothetical change in tourism demand resulting from DSM on Fiji's tourism industry. To the best of our knowledge, no study has hitherto employed the CB method to investigate how individual perceptions of anthropogenic activities, whose environmental impacts remain unknown, affect future tourism demand for coral reefs. Perhaps the most similar studies published to date are those of Piggott-McKellar and McNamara [47], who found that 70% of visitors to the Great Barrier Reef were strongly motivated to visit the Reef before it degrades due to climate change (a phenomena known as 'last chance tourism') and Reineman and Ardoin [49], who investigate surfers' perceptions of place-attachment and attitudes toward environmental issues on California's beaches. The latter study concludes that failure to sustainably manage surf-spots puts billions of dollars of surfer-related contribution to the Californian economy at risk.

The paper is organized as follows. First, a review of DSM's potential environmental impacts and tourism as a key industry in Fiji is conducted. Second, the CB methodology and questionnaire design are described. Third, the results of the survey are outlined and discussed. Finally, lessons drawn for future policy and decision making in tourism, coastal management and DSM are discussed and contrasted to the findings of previous tourism research.

1.1. Deep sea mining – opportunities and uncertainties

DSM is a comparatively new process, where valuable metals such as zinc, gold, copper and silver are extracted from the ocean floor. DSM can take place in the parts of the deep ocean floor that are rich in deposits of SMS. SMS deposits are found along mid-ocean spreading ridges such as the along the Manus Basin in Papua New Guinea and the Mid-Atlantic Ridge in the Atlantic Ocean [41]. SMS deposits have also been explored in the Atlantis II Deep of the Red Sea between Saudi Arabia and Sudan [8,25]. Other sources of metals found in the deep sea include polymetallic nodules, manganese crusts and massive consolidated sulphides and metalliferous sulphidic muds [2]. The International Seabed Authority has granted DSM exploration licenses for more than 1.5 million km^2 of the Pacific Ocean floor alone, but explicit licenses to mine the ocean floor had only been granted for Papua New Guinea, at the time of writing [17,27].

Profits from DSM are likely to be considerable in specific geographical locations. Bertram et al. [8] estimate that the Red Sea alone holds metal deposits worth approximately three to five billion USD. The manganese crusts found in the Pacific Ocean are more plentiful and of a higher quality than in most other parts of the world, suggesting a very high commercial potential for DSM activities in that area [2] and reports suggest that Nautilus Minerals are expecting to obtain more than one billion USD in revenue per year from the Solwara 1 Project [45].

However, despite the alluring promise of high profits, DSM is subject to severe criticism from certain stakeholders, particularly in regard to the environmental impacts that DSM is likely to have on marine ecosystems. The World Bank [55] has urged governments to adopt the precautionary principle before granting future licenses to mine the ocean floor, due to the high level of uncertainty of DSM's environmental impacts on marine systems. DSM involves cutting through, removing and disturbing large parts of the ocean floor in order to extract the mineral resources [2,23,36,52,56,66]. As illustrated in Fig. 1, DSM involves three key components: a mining vessel with a platform on the surface of the ocean, an underwater lift system which consists of a pipe-string/lift-pipe and a buffer, and a robot-seafloor miner that collects the mined metal deposits [44,66]. Moreover, the process requires a waste water circulation system [44]. As a result of the extraction process, the ocean floor may experience several types of damage from the mining process, including direct benthos damage,[1] resedimentation and discharges of particulates [66]. Other potential damages to marine ecosystems from DSM include upwelling and pollution [36,44]. Several studies [2,23,25,26,56,66]) emphasize that DSM is likely to impose severe and irreversible damage to marine ecosystems.

Other anticipated effects from DSM include reduced water clarity, toxic disturbances of water quality, and a change of habitat conditions of the ocean floor [23]. It should be noted, however, that the vast majority of studies seeking to explore the effects of DSM on marine environments have failed to produce sufficient evidence to detail or quantify with any precision the environmental effects of DSM on marine ecosystems. For example, in the 1970s and 1980s three major experiments involving environmental risk assessments of DSM were carried out in order to investigate the degree to which DSM would impact on the ecology of the deep sea, and to identify the nature of those impacts. The Deep Metalliferous Sediments Development Programme (MESEDA) and the Deep Ocean Mining Environmental Study (DOMES) took place in the Red Sea and the Pacific Ocean, respectively. Although both experiments advanced knowledge of deep sea ecology, the results were inadequate to specify exactly how DSM affects marine ecosystems, mainly due to the small scale of both projects [2,56,66]. The Disturbance and Relocation Experiment (DISCOL), initiated in the South Pacific Ocean at depths of around 4140 m [57], aimed to generate disturbances and changes in the deep ocean floor similar to those expected from DSM [2,56,66]. Although changes were observed in the hard bottom fauna which indicated that some flora might not have been able to survive the disturbances and other modifications in deep sea fauna were observed, a thorough scientific evaluation of the environmental impacts was not feasible due to the high number of unknown and rare species that live in and around the deep ocean floor [2,56].

Other experiments [11,38,44,57,6] have been conducted with similar objectives, but have produced limited scientific evidence on the environmental impacts of DSM. Despite this lack of evidence, experts remain sceptical that DSM can be carried out in a manner that does not harm marine ecosystems [26,56,60,61]. In an eloquent statement illustrating how a lack of scientific evidence coupled with great uncertainty has shaped public perceptions of DSM's potential impacts on marine ecosystems, [56] note "At this stage we remain bound by our imagination".

1.2. The significance of the tourism industry in Fiji

Fiji covers approximately 18,333 km^2 in landmass, and has a coastline of around 1130 km^2 [32,53]. The Fijian archipelago comprises several hundred islands, islets and cays, with 106 islands currently inhabited. The capital, Suva, is situated on the main island of Vitu Levu which, together with the island Vanua Levu, covers around 87% of Fiji's land mass, and are home to approximately 85% of the Fijian population [53]. The majority of Fijians rely on the ecosystems services provided by marine environments.

Although classified as a developing country, Fiji is one of the most economically developed countries in the South Pacific, and also one of the most attractive for tourists and travellers [62]. According to the Fiji Bureau of Statistics [18], tourist arrivals in Fiji amounted to 754,835 in 2015. The industry plays a critical role in the economy, in 2015 directly contributing 14.1% of GDP (2016 USD 588.4 million), with a total contribution of 38.7% (USD 1.62 billion) – the latter figure is forecast to

[1] *Benthos* refers to the collection of organisms that either live on or in the ocean floor, including flora and fauna.