

Paper:

Mitigating Impacts of Climate Change Induced Sea Level Rise by Infrastructure Development: Case of the Maldives

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Of the four atoll countries in the world, the Maldives has the lowest average elevation. Therefore, it is likely to be the first country to lose its land when the sea level rises due to climate change. As a countermeasure to sea level rise, the government of the Maldives is constructing an artificial island called Hulhumalé by raising an atoll adjacent to the capital city of Malé. Other atoll countries may employ the same method to adapt to the anticipated sea level rise. There is a concern that people who are forced to relocate to the artificial island will be affected in various ways. Therefore, the purpose of this study was to identify measures to reduce the potential impacts of migration to artificial islands. This study aimed to identify factors that will work effectively to satisfy migrants from outside the Malé region to Hulhumalé. At this stage, sea level rise is not a motivating factor for migration to Hulhumalé. For the time being, enhancing high-income employment and high-level education in Hulhumalé, which are the main motivations for migration, will help sustain voluntary migration. Over the past two decades, rapid economic growth has changed the desire of Maldivians. Hulhumalé is attracting people with its new urban environment and employment opportunities. A small-scale questionnaire survey on the satisfaction level of post-migration life was conducted among the residents of Hulhumalé and the results showed that those who changed their jobs before and after migration were less satisfied with their migration than those who did not. In Hulhumalé, smart cities are being developed and new types of employment are being created. In order to facilitate the smooth migration of residents from remote islands, policies that focus on occupational changes before and after migration are needed, such as public job placement programs that enable migrants to find the same jobs that they had before migration, and job training programs that prepare them for career changes and enable them to adapt smoothly to new jobs. At present, mental health issues among migrants are not a major problem. Strengthening people-to-people networks through the use of information technology (IT) will contribute to smooth migration and resettlement.

Keywords: sea level rise, atoll country, migration, Hulhumalé, Maldives

1. Introduction

1.1. Impacts of Sea Level Rise on Atoll Countries and Countermeasure Options

Four countries in the world have their entire land mass made up of atolls; these include Kiribati, the Republic of Maldives, the Marshall Islands, and Tuvalu. Atoll countries are highly susceptible to climate change and the impacts of sea level rise (SLR) primarily because of their low-lying lands. Most atoll countries are likely to become uninhabitable by the end of the 21st century. There is a possibility that the global mean SLR will rise to 2 m by 2100 and 5 m by 2150 [1]. This further emphasizes the urgency to implement adaptational measures for atoll countries. The Republic of Maldives, whose elevation is the lowest among the four atoll countries and where 80% of the islands are less than 1 m above mean sea level [2], will be the first country to face threat to the livelihoods of its residents.

The ramifications of SLR are assumed to manifest in various ways, such as land loss and threats to human settlements, shutdown of critical infrastructures, inaccessibility to water resources, loss of coral reefs, damage to agriculture, fishery and food security, threat to human health by vector-borne disease, and damage to tourism [2].

Atoll countries may have the following four options to cope with SLR [3].

- i. *Migration to the developed world.*
- ii. *Migration to other island states.*
- iii. *Land reclamation and raising.*
- iv. *Development of floating platforms.*

The Marshall Islands has a bilateral agreement with the United States called the Compact of Free Association (COFA), which allows Marshallese to migrate freely to the United States without a visa [4]. Therefore, approximately one-third of the Marshallese immigrants have immigrated to the United States [5].

More than 70% of the households in Kiribati and Tuvalu felt that migration would be a likely response if droughts, SLR, or floods worsened [6]. However, there are less than 5,000 (~4% of the resident population) Kiribati migrants. In Tuvalu, migrants comprised of ~19% of the resident population in 2019 [7].

1.2. Choice of the Maldives: Hulhumalé

The Maldivian government has chosen to build an artificial island called Hulhumalé in an atoll next to the capital Malé as a measure to cope with SLR.

The construction began in October 1997 and was completed in June 2002 (Phase 1) [8]. A new land of 188 ha was built by pumping sand from the seafloor onto a submerged coral platform that rose approximately 2 m above sea level, which was twice as high as Malé [8, 9].

After the success of Phase 1, Phase 2 commenced in 2014 and was completed in about a year [8]. This time, 244 ha of new land was reclaimed, and its focus was on the expansion of economic, commercial, and residential areas [9]. The total cost of Phase 1 was US\$32 million, which was financed entirely from the national state budget. For Phase 2, which was implemented by the state-owned Housing Development Corporation (HDC), investment costs are 160 million USD [10].

After the completion of Phase 1 in 2004, the first 1,000 people officially migrated to Hulhumalé [8]. According to a document issued by the HDC, the population of Malé was 98,744 in 2020. This number is expected to increase to 129,560 by 2023 [11]. By the mid-2020s, 240,000 people are expected to live in the city [8]. Some estimates suggest that 80% of the Maldivian population will migrate to the Greater Malé region [12].

As mentioned above, Hulhumalé has been created at a height of roughly 2 m above mean sea level, which is approximately 0.5 m higher than the average height of natural islands. According to Brown et al., Hulhumalé is likely to be safe from flooding during the 21st century as long as the sea level rise is restricted to less than 0.6 m [13].

In addition to coping with SLR, other crucial reasons for the Maldivian government to embark on such an unprecedented project, instead of abandoning the land and migrating to another location, are as follows.

First, it mitigates the dense population of the capital [14]. The city of Malé is notorious for being one of the most populated cities in the world [14]. Unlike people's image of Maldives being a luxurious beach resort, the capital has problems of public security, hygiene, and living conditions, primarily from dense population conditions [8, 15]. Hulhumalé may solve this problem by offering a larger land to disperse the population that is also well-managed [15].

The second is to make Hulhumalé the economic and administrative center. Presently, it consists of an international airport; in the future, it will have a commercial and economic zone, and a marine hub for tourist boats [9, 16]. HDC is trying to attract major investments in Hulhumalé [11]. The land developed in Phase 2

will be used to provide employment to approximately 85,000 people [17]. The smart city project, launched in 2017 by HDC (in collaboration with Qatar's telecom company Ooredoo and UNDP), is one of the highlights of the project [18]. In 2021, Ooredoo launched a new data center in Hulhumalé Smart City [19].

Finally, although it is not articulated, the government is promoting migration in order to bring the population (which is scattered across 200 islands) under the government's control [15].

1.3. Objectives of the Study

Other atoll countries may employ the same method as the Maldives to adapt to the anticipated SLR due to climate change. In such a case, there is a concern that people who are displaced from their original place of residence to the artificial island will be affected in various ways. Reducing the impact of migration and helping migrants transition to their new lives are key factors for an atoll country when considering the option of an artificial island. Therefore, the purpose of this study was to identify measures to reduce the potential impacts of migration in artificial islands. This study aimed to identify measures that work effectively to satisfy migrants that move to Hulhumalé.

2. Materials and Methods

2.1. Literature Review

Statistical data provided by the Maldivian government were analyzed (a) to obtain information on the changing lifestyle preferences of Maldivians and the varying conditions in the Malé region, including Hulhumalé, and (b) to examine ways to promote migration from islands other than Malé and settlement in Hulhumalé.

2.2. Survey by Questionnaire

A questionnaire survey was conducted to investigate the factors that accounted for changes in life satisfaction in those who migrated to Hulhumalé.

The questionnaire for the satisfaction is presented in **Fig. 1**. The survey was conducted online from May 8 to 23, 2021.

Questions were related to the characteristics of the respondents, including gender, age, years of residence in Hulhumalé, place of residence before migration (Malé/Island in Maldives other than Malé/Outside of Maldives), intention to migrate abroad before moving to Hulhumalé, and occupation before and after migration to Hulhumalé. With regard to the level of satisfaction after moving to Hulhumalé, respondents were asked to self-evaluate their life changes resulting from the move to Hulhumalé. They were asked to rate their satisfaction on a 5-point Likert scale, ranging from "worse" to "better."

2.3. Interviews

In order to obtain information on the current status of migration to Hulhumalé and details to evaluate the results

	Worse	Slightly worse	Same	Slightly better	Better
Housing	1	2	3	4	5
Convenience of everyday life (Ex: Shopping, transportation, access to public facilities)	1	2	3	4	5
Purchasing Power (the financial ability to buy products and services)	1	2	3	4	5
Availability of food	1	2	3	4	5
Safety	1	2	3	4	5
Opportunity for education	1	2	3	4	5
Social services (Ex: Social insurance, welfare, nursing, consultation)	1	2	3	4	5
Health care	1	2	3	4	5
Employment opportunity	1	2	3	4	5
Family relationship	1	2	3	4	5
Opportunity to participate in religious ceremonies	1	2	3	4	5
Opportunity to participate in community events	1	2	3	4	5

Fig. 1. Questionnaire sheet to assess satisfaction after migration to Hulhumalé.

of the questionnaire, interviews were conducted with four individuals who had extensive knowledge of Maldivian society and Hulhumalé. The interviewees were presented with a summary of the results of the survey and asked to interpret the results.

The attributes of the four interviewees are as follows: (a) a resident of Hulhumalé who has been in the diving industry for many years, (b) a person who has been in the fishery business, shuttling between the Maldives and Japan for many years, (c) a person who was in remote atoll as a Japan Overseas Cooperation Volunteer for two years, and (d) a researcher knowledgeable about the Maldives. All of them were Japanese. The interviews were conducted online, under the condition of anonymity, between July 2021 and September 2021.

3. Results

3.1. Literature Review

The increment in the employee-to-labor-force ratio (“employee” represents the total number of people in employment, excluding employer/owner [with employees], own-account worker, own-account worker [with family members], contributing family worker, group worker) was observed to be steady, that is from approximately 20.7% in 2000 to 47.6% in 2006 to 71.7% in 2019 for the Maldives as a whole [20–22]. In the Malé region, the number of employees increased tenfold between 2000 and 2006, and the employee-to-labor-force ratio skyrocketed from 9.8 to 67.1% [20, 21]. The rate in other regions increased from 25.4% in 2000 to 63.5% in 2019 [20, 21].

The national average income grew by almost 240% between 2003 and 2019 [23–25]. In the Malé region, between 2003 and 2010, the average income grew by 150%, while other regions saw an increase of approximately 18% [23, 24]. The income gap between the Malé region

and the other regions, which was about 200% higher in 2003, widened to about 250% in 2010, and has remained at 200% from 2010 to 2019 [24, 25].

Furthermore, this study compared the number of workers by region and industry in 2000 (before the start of migration to Hulhumalé) and 2019 [20–22]. Overall, in agriculture, forestry, and fisheries industries, other regions had higher number of workers than the Malé region, with 95% of the nation’s total workers in the other region from 2000 to 2019 [20–22]. Compared to other industries, the growth in the number of workers in this industry was marginal [20–22].

In terms of the number of workers by industry in 2019 [22], the Malé region had a tertiary sector that accounted for about 85% of the total number of workers, which was much higher than the other regions (65%).

The number of people working in the finance and business services category has increased by more than 1,400% in the Malé region since 2000 [20–22]. In 2019, more than 80% of the total number of people engaged in information and communication, financial and insurance activities, real estate activities, and professional, scientific and technical activities lived in the Malé region [22].

The number of workers in wholesale and retail trade has increased significantly across countries [20–22]. In the Malé region, it has increased by 3.8 times, whereas, in the other regions, it has tripled.

The accommodation and food services industry is growing strongly in the Malé region but is declining the other regions [20, 22].

As for education and health care, since there are no data for 2000, data for 2006 was used. While both have shown significant growth nationwide, the rate of increase in the Malé region is much higher than that in the other regions [21, 22]. In particular, the rate of increase in health-care is remarkably high at 385% [21, 22].

In the Malé region, the number of people working in transport, storage, and communication increased by ap-

Table 1. Satisfaction of migrants regarding convenience of everyday life, healthcare, social services, and food by origin.

		Convenience	Health care	Social services	Food
Median	Origin: Malé	3	3	3	3
	Origin: Other atolls	5	5	4.5	4
<i>p</i> value (Wilcoxon–Mann–Whitney test)		< 0.05	< 0.05	< 0.05	< 0.05

proximately 300% between 2000 and 2019 [20–22].

The ratio of registered population to census population in Malé, which was 56% in 2000, decreased to 36% in 2014 [20, 26].

3.2. Survey by Questionnaire

The questionnaire received responses from 47 residents who lived in Hulhumalé.

Here, we briefly describe the attributes of respondents. 21 respondents were men and 26 were women. Most respondents were in their 30s. Furthermore, the number of years of residence of the respondents in Hulhumalé ranged between 1 year and 17 years, with the average being 8.5 years. Before moving to Hulhumalé, 17 respondents lived in Malé, 25 lived on islands other than Malé, and 5 lived outside the Maldives. In addition, nine respondents answered “yes” and 38 answered “no” to the question on whether they had considered moving abroad.

Questions regarding occupation before and after migration were asked to see if there was any difference between the two. In terms of life satisfaction, the scores were calculated using a 5-point Likert scale.

As shown in **Table 1**, migrants from other islands are more satisfied than those from Malé regarding convenience of everyday life, healthcare, social services, and food.

Respondents who migrated from islands other than Malé were divided into those whose occupation had changed before and after migration-and those whose occupation had not changed.¹

Some of the migrants from other islands changed their occupation. They are less satisfied than those who did not change their occupation after migration (**Fig. 2**).

The factors with the largest difference in satisfaction between those who changed and those who did not were education > purchasing power > social services.

Regarding the psychological impact of migration, respondents were asked about family relationships, opportunities to attend religious services, and opportunities to participate in community events. However, many respondents answered “same,” making it difficult to identify clear trends by respondent attributes.

3.3. Interviews

Many people are aware of the fact that the Maldives is on the verge of SLR, partly due to government publicity.

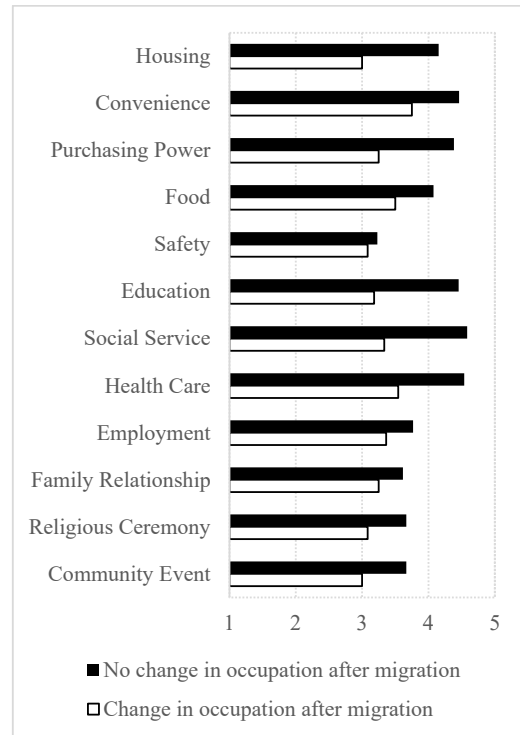


Fig. 2. Average score on a five-point scale (1 to 5) for each item according to whether there was a change in occupation in island other than Malé.

However, there is only few people who have a sense of urgency. SLR is still not the main motivation for people to move to Hulhumalé. For now, it is unlikely that they will leave their islands voluntarily because of SLR [27–29].

Many people migrate to Hulhumalé in search of better jobs, as there are more jobs available in the more populated urban areas than on the islands [28]. In recent years, the number of fishers has been decreasing because young Maldivians, in particular, do not like to do hard physical work. This is one of the reasons why people are migrating to the urban area of Hulhumalé [27, 28, 30].

Since Maldivians have a strong attachment to the island of their origin [27, 30], many will move to Hulhumalé temporarily and plan to return to their original island in the future. Whether they will settle in Hulhumalé remains to be seen [28].

In general, Maldivians not afraid of changing jobs, and are in search of higher salaries and better working conditions. As there is no official job placement program, new

1. Change in occupation after migration (12 respondents) and No change in occupation after migration (13 respondents).

jobs are usually found through personal connections [27–29].

Many people cite education as a reason for in-country migration. Furthermore, the younger generation is keen on education [27]. Even in remote islands, distance learning is available via the Internet; however, many people think that they need to relocate to Malé or overseas to receive specialized higher education [28].

The standard of living has drastically improved in the outlying islands. However, Malé and Hulhumalé have a greater number and variety of stores, restaurants, and schools than the outlying islands, providing a wider range of choices for people. The standard of living and educational opportunities continue to make Malé and Hulhumalé attractive to migrants from other islands [28, 29].

Most people who consider moving to Hulhumalé from other islands already have relatives or acquaintances there [27–29]. As Hulhumalé is not a very large island, it is easy to visit acquaintances [30]. Communication through information technology (IT), which has developed greatly in the Maldives in recent years, has also encouraged people to join the community of acquaintances in Hulhumalé, while maintaining a relationship with the community to which they originally belonged [27].

In addition, Maldivians are generally skilled in building new relationships; moreover, no one reported feeling lonely or isolated after moving to Hulhumalé [27–29]. While the Maldivian people have strong family and local communities, there is little group pressure to conform. They tend to value and act in accordance with their individual selves, and those around them tend to accept it [27].

As almost 100% of Maldivians are Sunni Muslims; there is no religious division between the community and individuals. In addition, there is no difference in religion by region; religious activities in Hulhumalé are likely to be the same as before migration [30].

4. Conclusion

According to the results of the literature review, the Greater Malé region, including Hulhumalé, has witnessed a shift in industrial structure from primary and secondary industries to tertiary industries; this has been observed throughout the Maldives in the last two decades. In particular, there has been a significant increase in the number of people employed in business services, such as finance, education, and health services. Furthermore, the average income in the region has improved significantly.

The results of the survey by questionnaire show that among people who have migrated to Hulhumalé from other islands were more satisfied with their lives than those who moved from Malé to Hulhumalé. Among the migrants from other islands, those who changed their jobs were less satisfied with their lives than those who did not change their jobs after migration to Hulhumalé.

According to the results of interviews with people knowledgeable about Maldivian society and Hulhumalé,

the major motivations for migrating to Hulhumalé are education and employment, and not SLR. Hulhumalé is a highly attractive destination for Maldivians to migrate to, and many people are moving there voluntarily. The problems of isolation and loneliness associated with migration to Hulhumalé have not been considered.

5. Discussion

5.1. Steps Needed to Encourage Voluntary Migration and Resettlement

According to the results of the questionnaire survey and interviews, Hulhumalé is attractive to migrants from outside Malé because of its favorable job conditions, convenient living conditions, good health care services, social services, and education. There is little sense of urgency about SLR, and it has not been a motivating factor for migration. On the other hand, a previous study showed that 25% of people from the Marshall Islands, which is an atoll country like the Maldives, said that climate change was the reason for their migration to the United States [31].

This section examines the changes in people's aspirations and measures that can be taken to respond to them. As Malé is overcrowded, major changes are likely to be implemented in Hulhumalé.

In the Maldives, the employee-to-labor force ratio has been increasing, suggesting a change in peoples' means of livelihood; that is, more people are seeking to be employed by someone. This increase in the number of employees and the employee-to-labor-force ratio in the Malé region between 2000 and 2019 is remarkable, indicating that significant employment is being created in the region. Ensuring continuous employment is also necessary to cope with the increasing number of migrants in the future.

Most of the workers employed in the primary industries, including fishery, reside outside Malé. The number of people engaged in primary industries has not increased significantly compared to other industries. This is consistent with the findings from the interviews that people no longer prefer manual labor, such as fishing. To encourage migration, it is necessary to create employment that is attractive to those who have traditionally worked in these industries.

In the Malé region, growth in the financial and service sectors is particularly pronounced. In addition, the number of highly skilled professionals is much higher in Malé than in other regions, which is one of the factors contributing to the income level in this region. The availability of high-income jobs attracts migrants. Such white-collar jobs in Hulhumalé will also be a factor in attracting young people, especially those who do not prefer manual labor.

Higher average incomes and higher employee-to-labor-force ratios are likely to bring about changes in people's consumption behavior. The significant rise in the number of people working in wholesale and retail trade across the country indicates that commercial activity is increas-

ing. Commercial development on new land that has become available in Hulhumalé will be required to provide more consumption options. In fact, the number of workers in wholesale and retail trade as well as accommodation and restaurant industries in the Malé area is increasing rapidly, leading to an increase in the urban attractiveness of Hulhumalé.

The Maldives has witnessed a rapid rise in the number of education and healthcare workers. The rate of increase is particularly high in the Malé region. To attract people who are interested in education and healthcare services, Hulhumalé needs to continue to focus on the above two areas.

In the future, for the Maldivian government to promote migration to Hulhumalé as a countermeasure against SLR, it is necessary to provide accurate information to the people and build a consensus on migration. For the time being, it will be efficient to improve employment opportunities and education, which are currently the primary motivations for migration. It would be ideal to use the new land in Hulhumalé to promote new high-value-added industries, increase employment (especially white-collar jobs), and attract high-level educational institutions from abroad.

5.2. Steps Needed to Increase the Level of Satisfaction After Migration

The results of the questionnaire survey indicate that the presence or absence of job changes before and after migration has a significant impact on the post-migration satisfaction of migrants from islands other than Malé. This is not necessarily consistent with the results of the interviews, which show that many Maldivians are not afraid to change their jobs and are in search of better salaries and working conditions. The reasons for this are supposed to be as follows:

1. The questionnaire selected respondents who had moved to Hulhumalé, whereas the interview secured information on Maldivians, in general. In future surveys, the target group for the questionnaire and interview should be homogeneous.
2. The fact that Maldivians are not afraid of changing jobs does not mean that they are free from stress. In future surveys, it is necessary to clarify the psychological impact of job change due to migration by interviewing people who have changed jobs due to migration.
3. There is a possibility that other factors may also affect the level of life satisfaction after migration. It is necessary to precisely investigate the impact of job change by surveying respondents with the similar attributes, besides job change.

Previous studies have suggested that migrants even within the same country tend to suffer from the psychological effects of migration [32]. The same is likely to be true for climate migrants from their original place of

residence to an artificial island like Hulhumalé. Future research should examine whether such impacts can be reduced by mitigating the stress experienced by migrants due to changes in their jobs and workplaces.

In the future, as new industries develop in Hulhumalé, it is expected that the percentage of people whose jobs will change due to migration will increase significantly. Currently, migration to Hulhumalé is voluntary, but there is a possibility that the number of involuntary migrants will increase in the future. Thus, it may become necessary to accept migrants with more diverse income levels and abilities.

There is an urgent need for career mediation programs to enable migrants to secure jobs that are similar to their previous ones, vocational training programs to enable people to adapt smoothly to new jobs, and the development of human resources to handle high-level jobs.

So far, those who have migrated to Hulhumalé have not experienced problems of isolation, loneliness, or other psychological crisis. Furthermore, friction from cultural and religious differences has not become a major problem. This may be due to the temperament of the Maldivian people and the uniformity of their religion.

According to statistical data, the number of transportation workers in the Malé region has been increasing. This is probably due to the development of the transportation network that connects the Malé region with the rest of the country, starting from Hulhumalé. Further research should examine the possibility of mitigating the psychological impact of migration by providing a convenient transportation facility between the place of origin and Hulhumalé.

Since migration to Hulhumalé has been ongoing for quite a few years, new migrants can easily find relatives and acquaintances who have already moved to Hulhumalé. This should help reduce the psychological impact of migration on immigrants and alleviate the stress experienced by the host community in absorbing the immigrants. Another effective strategy is to use IT to strengthen people-to-people relationships so that migrants can integrate smoothly into the existing community and have reduced psychological impact of migration.

The decline in the ratio of registered population to the census population in Malé region may indicate an increase in the number of people migrating to Malé region as “migrant workers.” This is consistent with the results of the interviews. They believe that they can leave Hulhumalé at any time, so the stress of migration would be low. This may be one of the reasons why the psychological problems of migrants have not surfaced so far. In the long term, the current situation may change with SLR.

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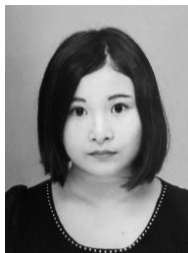
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