Climate change adaptation: Daku village case study, Republic of Fiji.

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Abstract

Over the years, it is argued CIEL [2] that humanity is conducting an unintended but uncontrolled globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war. The Earth's atmosphere is being changed at an unprecedented rate by pollutants resulting from human activities. These changes represent a major threat to international security and are already having harmful consequences over many parts of the globe. The environment upon which we live and on which our continuing existence depends has limited capacity therefore, mankind can hardly afford to continue to consider it as a resource to be exploited for short-term irretrievable profits. If we are to enjoy a safe and a successful life on the planet Earth then, we must use the limited resources at our disposal wisely, by being good stewards of our own environment. Our environment has been intimidated by our actions and the need to better manage it has been debated widely and vigorously in recent years.

Even though natural forces can influence and shape our environment, it takes a long period of time for us to realise the changes that have occurred except for the changes caused by natural calamities. In contrast, humankind has now been condemned for rapidly changing our environment and annihilating the non-renewable resources. It is therefore necessary that our actions in relation to our environment should be managed properly such that we as well as the future generations may enjoy what nature has preserved.

This paper contributes to the global efforts to combat and mitigate the effects of climate change especially the impacts on the life and health of people in developing countries. Thomas and Twyman [3] claim that considerable amount of literature has suggested that the poorest and most vulnerable communities, mostly in developing countries, will disproportionately experience the adverse effects of the 21st century climate change.

Introduction

The fatal flood events that devastated the northern and western parts of Viti Levu, the largest island in the Republic of Fiji, in 2012 have proven the vulnerability of the insular nations of the Pacific to changing climate patterns. In addition, during the second half of 2011, a severe drought occurred in the islands of Tuvalu, 1000 kms north of Viti Levu. The drought forced the Government of Tuvalu to declare that the country is in a state of emergency on September 28, 2011, due to severe water shortages in the capital. The drought also caused the contamination of thin fresh underground water lens that people were hoping to use as a last resort. These and numerous other recent events around the globe remind people living or doing business in small developing island states to be on constant alert and take precautionary measures to mitigate the adverse effects of unexpected and unwelcomed natural events. This paper contributes to the on-going global efforts to combat the unintended natural catastrophic events such as the climate change and the resulting sea-level rise.

The paper presents the result of an investigation to prove, to donors and decision makers, that the general ground level or height of the coastal villages along the Rewa delta, north-east of Suva in the island of Viti Levu, Fiji is lower than the height of sea level at high tide. It has been observed that the rise of sea level at high tide causes the villages to be inundated. This inundation issue is known to cause health and sanitation problems to affected coastal communities. The paper explains how a temporary tide gauge was installed to check the reference level for surveys in and around the area concern. The result of a topographical survey and the production of a triangulated irregular network and a contour plan of the village are presented. Determining the volume of infill materials that are needed to raise the height of the living area of the community will be presented later in a separate publication.

Physiographical setting

The archipelagic Republic of Fiji is located close to the south-west corner of Oceania. The country is situated some 2,000 km north-north-east of Auckland, New Zealand, 700 km north-west of Tonga and about 2,800 km north-east of Brisbane, Australia. Within the archipelago there are a series of subaerial volcanic islands, a number of raised marine volcanic islands and some coral limestone islands. The islands scattered between 12^o and 23^o south latitude and between 177^o east longitude and 178^o west longitude. The two main islands of Viti Levu and Vanua Levu comprise more than 80% of the country's total land area of about 18.300 km^2. The cone-shaped larger volcanic islands rise to over 1,000 m above sea level and most of the 800,000 population of the country live in coastal areas.

The Republic has a tropical climate with an average temperature of 26°C and an average annual rainfall of 2,200 mm. Fiji's economy ought to be based upon the resources of land and sea which abound in the tropical and sub-tropical parts of the Pacific. It is richer in natural resources than the neighbouring Tonga, Wallis & Futuna and Tuvalu with extensive forest reserves, rich volcanic soils, mineral deposits, fisheries and tourist attractive beaches. In a country like Fiji wealth is determined by the amount of agricultural and marine produce and manufactures one could control or call upon. It is widely known how favoured the country is in this respect. Its soil is very fertile and suitable for growing a large variety of tropical and sub-tropical crops. Moreover, its sub-tropical climate is excellent and its water supply, if properly managed, is sufficient to secure an abundant annual harvest.

Within the last two centuries, particularly since the end of the Second World War, Fiji has undergone considerable change owing to increasing exposure to foreign culture, their value systems and technology. Improvements to communication and transportation facilities have resulted in an increase in the tourism industry. These activities greatly supplement the country's agriculturally-based economy. However, the traditional cultures and customs of this island society are being rapidly eroded due to successive waves of Western civilisations forcing themselves upon the undefiled island nations of the Pacific.

Fiji is subject to earthquakes, landslides, cyclones, flooding and storm surges and is second only to Papua New Guinea as the Pacific Island state most affected by natural disasters since 1990. Johnston, Vos, & Wade [4] point out that natural hazards, made worse by inadequate environmental management, can affect the economic and technical viability of otherwise appropriate sustainable economic development activities.

Climate change: an overview

Adger, Hug, Brown, Conway and Hulme [5] claim that societal vulnerability to the risks associated with climate change may exacerbate on-going social and economic challenges, particularly for those parts of societies dependent on resources that are sensitive to changes in climate. The IPCC proclaims that there is now little doubt that human-induced climate change is happening. All societies consequently need to learn to cope with the changes that are predicted — warmer temperatures, drier soils, changes in weather extremes and rising sea levels.

Pacific islands urgently need to adapt to climate change and adopt mitigation options therefore, coordination and assistance is needed to assess and implement practical, affordable and maintainable options to solve the problems.

More research needs to be undertaken to understand climate variability, climate change and sea level rise through information, modelling and clearinghouse mechanisms. Such research identifies and assesses vulnerabilities as well as impacts.

Lim [1] rightly points out that in recent years, reducing vulnerability to climate change has become an urgent issue for the world's developing countries. Not only do these countries lack the means to cope with climate hazards, but their economies also tend to have greater dependence on climate-sensitive sectors, such as agriculture, water, and coastal zones. For these countries, climate change adaptation remains at the forefront of any sustainable development policy agenda. The process of adaptation is not new; throughout history, people have been adapting to changing conditions, including natural long-term changes in climate. What is innovative is the idea of incorporating future climate risk into policy-making. Although our understanding of climate change and its potential impacts has become clearer, the availability of practical guidance on adaptation to climate change has not kept pace.

The project site

Daku village is located at about 30 kms north-east of central Suva and 3 kms from the open ocean at the end of one of the branches that branched off Rewa river as shown on Figure 1. The village is accessible to vehicles via gravel road. A bus service operates everyday starting from seven in the morning. There is one small retail shop that provides the daily needs of the community including bread. There is also a primary school, a church and community hall.

Figure 1. Location of Daku village

It had been reported that at high tide, and worse during spring tides, the village is inundated with salt water. This is causing serious health and sanitation issues such as proper water supply, safe food supply, disposal of garbage and human waste, keeping the village clean, preventing the spread of diseases and preventing the spread of decomposition fluids (from decayed human body after burial) into the surrounding environment. The authors went to the project site during the August full moon on 2nd August 2012 to observe this phenomenon. Pictures in Figure 2 were taken during the visit.

Figure 2. Daku village during spring high tide

The pictures of Figure 2 above warrants further investigations. The School of Land Management and Development at USP was asked to lend a helping hand in determining the general level or height of the village.

Topographic survey of the project site

A topographic survey was carried out in 2012 for the purpose of creating a contour plan of the project site and the height or level, above mean sea level, of the floor of some of the buildings in the village. Determining the floor level of the houses is needed to locate how high, above water, the residents of the village live and sleep at high tide. This exercise does not consider or include fresh water lens, if any, in the investigation.

As stated in the preceding paragraph, the height or leveling work was made based on the "mean sea level" geoidal surface reference. A contact was made to the Lands & Survey Department of the Ministry of Lands, Mineral Resources & Environment to obtain the location of the nearest height/leveling benchmark to the project site. The authors were directed to the Land & Water Management Division (LWMD) of the Agriculture Department opposite Nausori airport. LWMD staff showed the authors a reference mark that they have established in the project site. The reference mark given has a Reduced Level (RL) of 1.98 above mean sea level (amsl).

The efforts, importance and the amount of money needed to deal with the problem facing by the inhabitants of Daku require a thorough investigation of the sea level at high tide. The next section explains how the tide gauge was established.

Temporary tide gauge

A temporary tide gauge was installed, as shown in pictures of Figure 3, to check the referenced level or height datum provided by the Department of Drainage & Irrigation (DDI).

Figure 3. USP staff establishing a temporary tide gauge at the project site

A 6 x 2 inches board was driven down in the mudflat, for more than one metre, and an adjoining 4 x 2 inches board was also driven down alongside the 6 x 2 inches board. The top or head of the 4 x 2 inches board was leveled to the mean sea level or 0.00 height reference datum. This was accomplished by transferring the level from the 1.98 m amsl reference mark provided by DDI using an automatic level, a leveling staff and a staff bubble. A check was made to ensure that the top of the 4 x 2 inches board is at 0.00 m or mean sea level by running a line of level between the top of the 4 x 2 inches board back to the DDI reference mark.

The bottom of an aluminum leveling staff was placed on top of the 4 x 2 inches board and secured to the protruding 6 x 2 board. The staff bubble was used to ensure verticality of the staff. A back-sight was taken to a second staff that was held vertical against the 1 m mark of the staff that has been fastened and to be used to monitor tide levels. A foresight was taken and a reading was made to the DDI reference mark. The difference in height was derived, from the readings, to be 0.978 m. This is 2 mm lower then what it should be and is considered acceptable for the purpose of the project.

Sea levels were continuously observed prior to and up until after high tide on two occasions before this paper was written. The first observation was made two days before a first quarter moon. The sea level was observed to be 0.995 m at its highest before the tide recedes. The sea levels for the same date were predicted for Suva, by the Australian Government Bureau of Meteorology (AGBoM), to be 0.4 m at low tide to 1.7m at high tide. The second observation of the sea level at high tide was made prior to and after high tide at full moon on the same lunar cycle. The sea level was observed to be 1.10 m at its highest before the tide recedes. The sea levels for the same date were predicted for Suva to be 0.2 m at low tide to 1.9 m at high tide.

The AGBoM has predicted that the sea level, at high tide during full moon period would be 2.00 m in the month of October and 2.1 m during the full moon in November and December. If we take the predicted sea level at high tide during the first tidal observation referred to above and divide it by two (1.7 m/2) we have 0.85 m, the value we would expect to read on the temporary tide gauge. Instead, the reading was 0.995 m which is 0.145 m higher than what it was predicted to be. Similarly when we repeat the same calculation for the second predicted sea level (1.9 m/2) we have 0.95 m, the value we would expect to read on the tide gauge. Instead, the reading was 1.10 m which is 0.15 m higher than what it was predicted to be. Further investigation is needed to clarify this anomaly. The difference appears consistent and on the same direction. If we add the 0.15 m, difference between the predicted and the actual readings, to the 2.1 m sea level predicted for November and December we are expecting the sea level to peak at 2.25 m or 1.20 m above mean sea level.

Data collection

The topographic survey was carried out by USP staff with a Nikon DTM-352 Total Station, two prisms, one prism pole and two tripods with telescopic legs. A handheld Trimble Juno GPS was used to orientate the survey to the Fiji Geodetic Datum 1986 system. Four traverse marks were placed and surveyed as control or instrument stations for data collection. So far, data collection were made at only three traverse stations and stored in the Total Station itself. The data stored by the equipment were the three dimensional X, Y and Z coordinates of each point picked, point ID or number and a feature code. Each spot height was given a G code for Ground surface and the floor levels were given FL code with the type of building whether school, church or residential. So far, a total of 316 spot heights and 32 floor level have been taken. It should be noted that during data collection it was very important that the instrument person enter the correct code for each terrain feature surveyed. This will help with separating the spot heights from the floor levels. Floor levels of some of the houses in the village are shown in the picture of Figure 4 below. The building in the middle the picture is the community hall and its floor is 1.238 amsl or 0.238 above sea level at high tide in August or 0.038 above sea level at high tide in November and December.

Spot heights were taken at selected location, especially where there is a change of grade. The spot heights ranged from -0.203 m (below mean sea level) at the lowest spot to +1.443 m (above mean sea level) at the highest location. The survey reveals that some parts of the village are below mean sea level and a large part is below sea level at highest high tide.

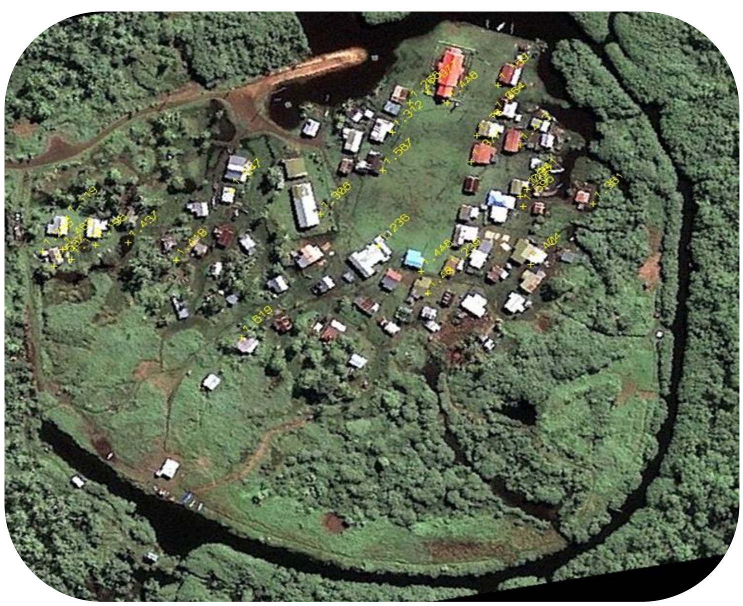

Figure 4. Floor level of some of the houses in the village.

Data Processing

The data, as collected in the field, were downloaded from the Total Station to a Desktop computer using the Trimble Data Transfer software as an Excel spread sheet comprising Point ID, x-coordinate, y- coordinate, z-coordinate and the feature code. The data was edited, re-formatted and processed using version 8 of the 12d Civil Engineering, Water Engineering and Land Surveying software. 12d uses the data to create a Triangulated Irregular Networks (TIN) meshes from raw XYZ data as shown in the diagram of Figure 5.

Figure 5. TIN meshes for Daku village

The ultimate aim of this exercise is to create a contour plan of the village to determine what could be done to improve the quality of life of the people living in the village. The TIN and the associated contour plan are also used to determine the volume of infilling materials that are needed to bring the ground level up to 0.3 - 0.5 m above sea level at highest high tide. Figure 6 below is a contour plan of the project site derived, in 12d, from the TIN of Figure 5 above.

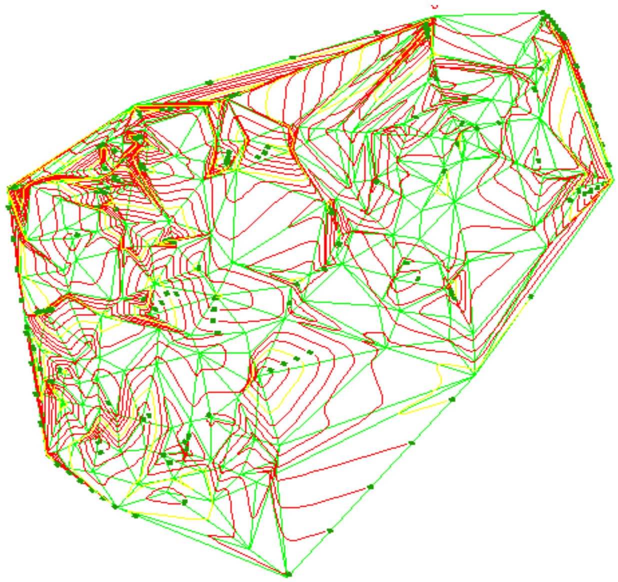

Figure 6. Contour plan of the project site

Conclusion

While recognizing the important roles that economic development activities play in increasing and enhancing the wealth of people in developed countries, the implications and impacts on the poor, in developing island nations of Oceania should be scrutinised to ensure that the latter is neither disadvantaged nor forgotten in the development chain. The study presented in this paper shows that urgent actions are needed to save the communities that are currently experiencing the effect of climate change. If this does not happen then the end result will be a rejection, by the intended communities, of the new techniques, policies and technology that have been formulated and developed by international agencies to mitigate the environmental and social impacts of climate change.

The research presented in this paper proves that the ground surface on which the dwellings of the people of Daku village is lower that the sea level at high tide. The topographical survey shows that some parts of the village are below mean sea level or halfway between low and high tides.

References

B. Lim (ed), “Adaptation policy frameworks for climate change: developing strategies, policies and measures, Cambridge, Cambridge University Press, 2004.

CIEL (Centre for International Environmental Law), “The changing atmosphere: Implication for global security conference statement”, The American University Journal of International Law and Policy, vol. 5 (2), Toronto, The American University of International Law and Policy, 1990.

D. S. G. Thomas and C. Twyman, "Equity and justice in climate change adaptation amongst natural-resources-dependent societies", Global Environment Change, 15, Elsevier, 2005, pp. 115-124.

P. Johnston, J. Vos and H. Wade, "Pacific regional energy assessment 2004: an assessment of the key energy issues, barriers to the development of renewable energy to mitigate climate change and capacity development needs for removing the barriers-Fiji national report", The Secretariat of the Pacific Regional Environment Programme, Samoa, 2004.

W. N. Adger, S Huq, K. Brown, D. Conway and M. Hulme, "Adaptation to climate change in the developing world", Progress in Development Studies, vol. 3 (3), Arnold, 2003, pp. 179-195.