

Original Research Article

Impact of Cyclone PAM on Rainwater Harvesting Prospects in the Pacific region

ABSTRACT

Aims: To assess the impact of cyclone PAM on the rainwater harvesting prospects in the Pacific region.

Study design: The study was conducted based on the field observations, data from various government organizations and NGOs.

Place and Duration of Study: The study was based in Port Vila, Vanuatu along with nearby Island countries like New Caledonia, Solomon Islands, Fiji and Tuvalu were part of the study. The study was conducted from mid-March to the end of June, 2015.

Methodology: The study was based on the field observations; estimates from authenticated sources with the evidence of the pictorial data of remote areas; community feedbacks; government department's data and NGO's reports. The views of individuals, community heads, government bodies and relief workers of various national and international agencies were integral part of this assessment.

Results: The impact of category 5 cyclone PAM on the prospects of rainwater harvest in the Pacific region was at the highest order. An average of 76% damage to these was recorded in the region.

Conclusion: A serious introspection had risen for the regional practices of rainwater harvesting in the Pacific and seems in bringing a drastic change for sustainable practices which would withstand the global changes. May be an integrated model with traditional setup and modern equipment shall make sure for sustaining future natural disasters besides longevity and for better prospects.

Keywords: Cyclone PAM; Impact Assessment; Pacific Region; Rainwater Harvesting

1. INTRODUCTION

Rainwater harvesting for drinking had been an ancient practice for human civilization. According to Pacey and Cullis [1], it is the gathering and storage of water running off surfaces on which rain has directly fallen, could be a potential alternative in small communities that cannot be served by more centralized water supply schemes. Meanwhile United Nations [2] observed that the climate-change has been impacting on water resources are especially troublesome for small island developing states. It is obvious of the observation refereeing to the Pacific region where the natural calamities having huge impacts. Pandey et al. correlated between heightened historical human efforts for construction of rainwater harvesting structures across regions in response to abrupt climatic fluctuations [3]. They further added that historical societal adaptations to climate fluctuations may provide insights on potential responses of modern societies to future environmental changes that have a bearing on water resources, food production and the management of the natural systems. Waller [4] reported that rainwater harvesting would be the best alternative source for drinking water in the developing and developed countries and Radhakrishna concluded it as a time-honored practice since ages [5].

According to Hunt's studies in Kiribati and Tuvalu countries of the Pacific region, the lack of management skills and poverty are making them to stick to the traditional methods in the rainwater harvesting [6]. On contrary Barron and Jessica reported that the technologies that can be of in-situ and ex-situ techniques to collect and store water depend on the cultural and developmental issues [7]. The same was being reported by Moglia et. al., as, the complexity in water supply methodologies and to be acquainted has been preventing many communities in the Pacific region to favor the traditional methods [8]. He further felt that the political uncertainty in these communities as well as at the national level was a major factor in bringing up any change in their livelihood. The under development might be an issue but the cultural dominance had not only been confined to rainwater harvesting but in all aspects of pertaining to the life style in the Pacific region. May be time and need shall decide the fate of systems, but already scarcity for the growing population has been evident in most of the regions of the Pacific. White et. al., felt that there were many limitations in the use and storage of harvested rainwater in Kiribati of the Pacific region [9], which reflects the status of the rainwater harvesting practices in the region.

But in the Pacific region, rainwater harvesting is considered as a mandatory set up in the civil planning and has been accepted widely at both public and private places. The same was being reported by Kim [10] in some places around the world. Stockholm Environment Institute (SEI) [11] refers the practice as a blessing from the sky whereas, according to Conserve Energy Future (CEF) was keen in reporting its disadvantages as well [12]. Radha and Bharat [13] had earlier observed the positive impact of rainwater harvesting on society, economy and ecology but, the recent impact due to the cyclone PAM had left prospects to decline in all ways in the Pacific region. Being mostly dependent on the monsoon for the water resources, the Island nation had been practicing the harvest culture as their reliable and main source of water. In view of the above, an impact assessment was conducted with focus on the extent and the contributing factors of the damage to rainwater harvesting. The cultural practices along with modernized review in harvesting besides a note on the challenges in the region were also considered in the evaluation. The role of the government and challenges for sustainable practices were also briefly discussed in the assessment.

Rainwater Harvesting in the Pacific region

Being a monsoon dominant region, the Pacific had been in its culture to have the rainwater to be harvested mainly for the drinking purpose. It is almost mandatory during any construction to have the system to be a part of the design. May it be a community one or of an individual, it has been the tradition with pride to be a part of one's life style. It had been based on the strong cultural impact with a belief of being with nature. People in the Pacific consider drinking the rainwater is more pious than any other form of water as they consider it the other form of God. It was being the same reported by Mosley of the South Pacific Geoscience Commission in his report as, in almost all Pacific Island countries properly collected and stored rainwater is likely to be superior to untreated surface and bore water supplies but this may not always be the case [14]. Obviously the extent of monsoon might be the reason in the Pacific region that makes the natural resource to their footsteps but the economic status establishes the fact of the modernization for supplied water is far behind the reality. But, now-a-days the government has been firm in implementing sustainable practices in protecting the natural resource in the region and is obviously of the pressure from the funding countries for varied benefits in their investments.

May be the systems might be changed with the generations but the practice remains still the same and shall remain so as a part of their rich cultural inheritance. It was observed that children in the Pacific are being told the stories of the harvesting and its advantages rather being just left to see and inculcate the tradition. Angrill et.al., observed the same and

83 reported that the cultural practices sometimes are the most environmentally friendly strategy
84 in rainwater harvesting [15]. It was prevailing here that being a part from the cave culture to
85 collect the water from outside, people used ditches on the ground on the plains. The reason
86 harvested water being given importance over the agriculture than for drinking is the constant
87 monsoon and shortage for freshwater resources in these areas. Now being a part of the
88 modernization, cement and plastic tanks with perfect roof channeling were being
89 implemented for the most output. The increased harvesting culture here had a reason of the
90 increased development of the intrusion zones by which salinity has been a problem and it's
91 obvious with being the Islands. It was also due to the development and disappearance of the
92 lagoons with seasonal fluctuations by the climate changes taking place in the Pacific region.

93
94 The peculiarity of the rainwater harvesting systems incorporation here are the open
95 collection types as the collected water can be accessed by anyone. Generally this is seen at
96 community based collective systems but people here are more open for those who are thirst
97 enough to collect and drink. The design shall have the system being placed in such way that
98 is accessible in a public way rather than considering it to be a private property. This had
99 been a drawback as the collecting channels run too long from the roofs. The supporting
100 structures with coconut strings or hangers with crawler stems often make them susceptible
101 to develop cracks due to gravity at various points. The intensity and flush rate of the
102 rainwater also affect the channel joints in these cases. In general, the individual systems
103 shall be of plastic tanks of varied sizes depending upon the economic status whereas the
104 communities based are of concrete. These too vary in their length and breadth based on the
105 size of the community or in some cases based the type of aid. Many international agencies
106 primarily focused on the construction of these systems as a part of their charity and the
107 dominant contributors are from Australia and New Zealand. Recently China is being actively
108 participating in these types of activities in the region.

109
110 The damage to the harvested systems by the natural calamities and the recovery are part of
111 the Pacific life style. There were instances of past like cyclone UMA in 1987 and a major
112 earth quake in 1992 where, irreparable damage was done not only to the rainwater
113 harvesting systems but to the people as well. Every time there was an awareness to meet
114 the calamities and to strengthen the constructions, poverty was one of the reasons on their
115 way all the time between the thoughts and actions. The cultural dominance over the
116 modernization has been a major factor to consider, as most of the communities still believe
117 that cultural heritage shall recon since ages for their prosperous lives in the region. May be
118 this would be a factor for most the people still depend on harvested water rather to use the
119 supplied water by paying. Even the general thumb rules of cleaning water by cloth filtering or
120 boiling were not being the part here before the consumption. There is still no momentum in
121 the spread of the awareness for clean drinking water and hope there would be soon enough.
122 Lye [16], Morrow et. al., [17] and Kwaadsteniet et.al., [18] reported the health implications of
123 direct drinking from the roof collectors but, belief from cultural heritage had been making the
124 scientific reasoning no value. On the contrary, Jones and Hunt reported that there was
125 recent interest in the southern parts of America in having rainwater harvesting systems for
126 domestic and agricultural use [19].

127 128 2. METHODOLOGY

129
130 The study was aimed to assess the extent of damage to the traditional rainwater harvesting
131 systems by the cyclone and thus the impact assessment was studied. The base of the study
132 was at the capital of Vanuatu, Port Vila and extended to the other Islands. Reports from the
133 nearby Island countries like New Caledonia, Solomon Islands, Fiji and Tuvalu were
134 considered in the evaluation of the impact (Fig. 1). The estimate was authenticated from
135 sources with the evidence of the pictorial data as these include the reports from the remote

136 areas without any communication facilities. The study was effective as it was done the next
 137 day from the impact and could gauge the damage as it stands. The views of individuals,
 138 community heads, government bodies and relief workers of various national and
 139 international agencies were integral part of this assessment.

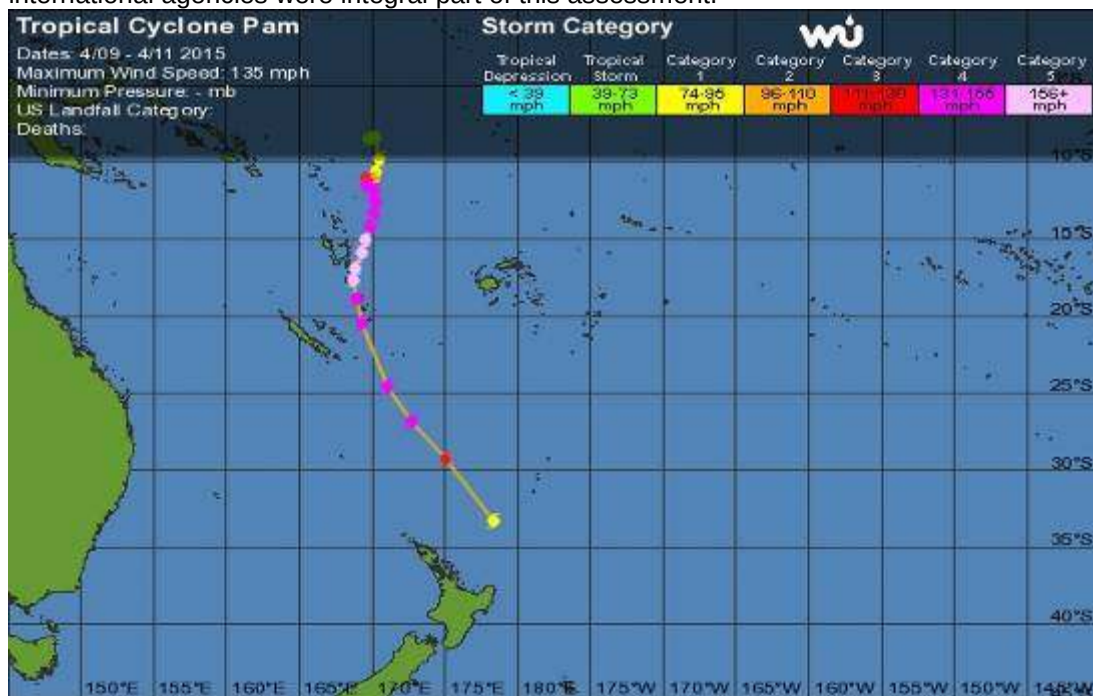


Fig. 1: Satellite image of the Pacific region Cyclone Pam

142 The earlier stages of the impact assessment were very difficult due to lack of transport
 143 facilities, flooding, curfew, reluctance to give feedback from some communities and so on.
 144 Care was taken in eliminating the harvesting systems which were already in damaged
 145 condition or which were being not used for some time and most of these include the
 146 community harvested systems. The onsite review in most of the Islands of Vanuatu gave
 147 sufficient information in the assessment and the extent of the damage was audited. These
 148 included the Islands of Tanna, Malekula, Espiritu Santo, Ambae and Pentecost.

149 3. RESULTS AND DISCUSSION

150
 151
 152 The cyclone PAM was a category 5 type and was considered a monstrous one that left most
 153 of the Pacific region countries devastated. It started at latitude of -8.5 and longitude of 169.8
 154 and crossed the bay at -33 and 178.3 in the Pacific region (Fig.1). With whirlpool winds over
 155 250 Km/h uprooted gigantic trees and seen them flown like cotton fibers. Port Vila, the capital
 156 of Vanuatu being in the eye of the cyclone had the destruction at its highest order (Fig.2).
 157 Being pith dark and unbearable whistles of the wind squirrels with heavy rain, it was a
 158 nightmare. The inner vision from the sounds of the flying roofs and collapses thought that
 159 one should never get off from their position and shall remain **where they are**. It would be
 160 nothing sort of a hell for the children **along the shores** who were to be covered under the
 161 fiber boats all night. It was a night where a single thought of 'survival' being prevailed all over
 162 the Pacific region. The Asian Development Bank had estimated that more than 50 million
 163 dollars of loss and damage occurred to the infrastructure besides personal and human loss.
 164 The UNO pronounced it as the loss of **an** unprecedented extent and would take decades to
 165 be refilled for the tiny Island nations. **The extent can be imagined as in the** preliminary
 166 reports said that over 70% of the harvest would have to be percolate down to the land or

merge into the sea. It was in one way a boost for the groundwater levels but been little use in the Pacific region.

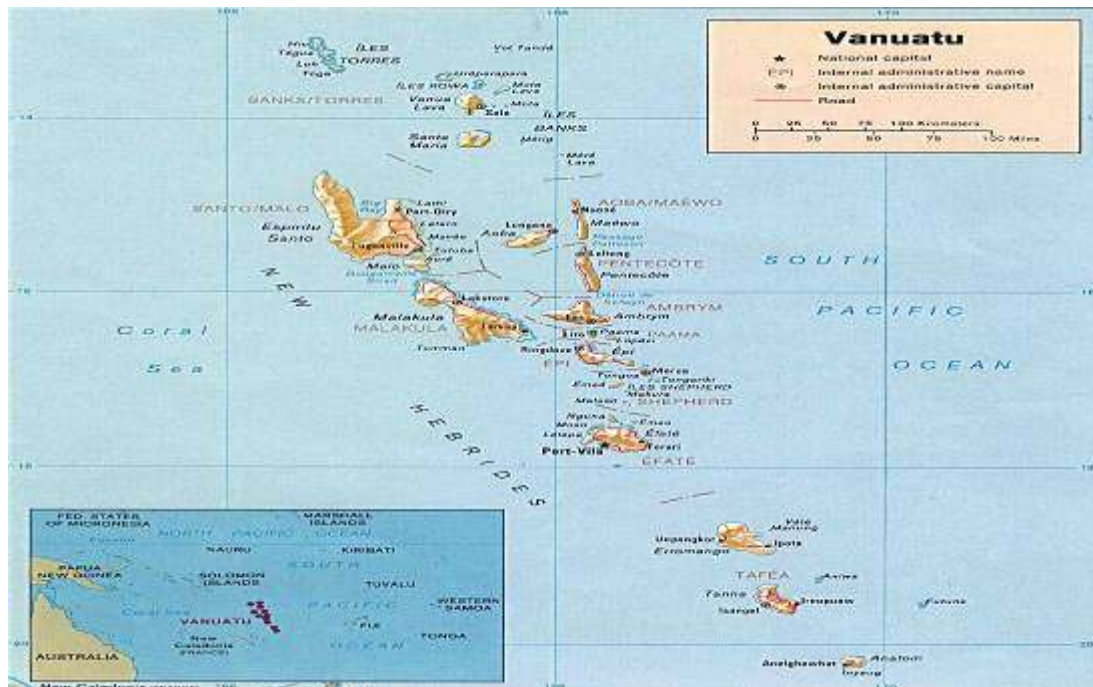


Fig. 2: Map of Vanuatu and other Island Countries

The magnitude of the damage was evident in the daylight as everything was down by the devastation. The survey of the private systems reached to an average of 84% along the coast and 69% in others areas with an overall estimated damage of 76% from the overall reports. The average damage recorded in the villages was around 62%. Tanna Island of Vanuatu recorded a maximum of 92% damage to its rainwater harvesting systems and Suva capital of Fiji Islands with a least of 11%. In Honiara of Solomon Islands at extent of 57% damage was recorded. In Tuvalu and New Caledonia countries the damage was around 43% and Fiji with the least of 18% were being assessed from the reported data. The damage being varied with the cyclone changing its direction without predictions and speed. This had made most of the preparatory arrangements in vain at most of the places. It was warned to be a category 3 cyclone at the most but, it had crossed the expectations of the Joint Typhoon Warning Center (JTWC) and recorded as 5. It was later announced of the deviation was of the sudden depression developed in the South Pacific Ocean. The misgauge in the warning had some serious impact on many places of the Pacific region and it was understood that the technological update is being seriously thought by the World Bank for the region.

The roofs were seen hanging on the tree tops was a clear report of the gale winds destruction and it was pity that the harvested systems main parts were now being collected from the debris. In the other regions of the Island, the community tanks in Ponga, Ekasup and Erakor villages near Port Vila were severely damaged. Out of the 22 public harvested systems here, 17 were completely ruined and others were damaged to an extent. The extent of preparatory arrangements made the difference in case to case besides, the approach in construction from the government expertise in some places had saved the day. The harvesting structures were being down by the collapsed coconut trees (Fig. 3) in the Northern parts of the Island. Earlier the same trees were excellent sources of rainwater and

199 protected from mild to strong winds, but they were the culprits this time around. The context
200 coincided with Evans et al., observation that, even though rainwater harvesting is an
201 environmentally sustainable practice but at times the environmental factors do magnify the
202 unwanted natural impacts as well [20]. It was learnt that the change in the direction of the
203 wind **in the** early hours doomed them. It was recorded that in most of the villages no traces
204 of the systems were observed and especially it was very severe in Mare in the New
205 Caledonia as well as Asau in Tuvalu. The NGO's of Australia **were** busy in rebuilding the
206 community harvested systems and learnt that they would be ready by the end of the year.
207



208
209 **Fig. 3:** A community collection center being damaged by the cyclone PAM
210

211 It was evident from the sites that the thin iron roofs and the plastic pipes never gave any
212 resilience at any point and obvious at the power of the monstrous cyclone. It was a common
213 picture around these countries where many of the houses were left **without** roof (Fig. 4).
214 Especially areas which were on the hill tops like Erkor mountain suffered the most.
215 Alternative water source from the rivers in absence of harvested rainwater was hampered by
216 the intrusion of salt water from the nearby lagoons. In many places the roofs and channels
217 were seen flowing through the overflowing rivers. The recovery was poor as of the plastic
218 being done to bit and pieces due to the flow rate. Most of the bays were seen heaped with
219 the roofing material, channels and torn plastic tanks of the harvested systems. It was
220 pathetic that neither the collection systems nor the utensils were left, though there was
221 sufficient rain for days after the cyclone. They were forced against their culture to have the
222 bottled water **but**, they had for the mere survival. In view of these cultural jinxes all over the
223 world Hay and Nobuo felt that, development can be made more sustainable by increasing
224 the ability of systems and societies to adapt to multiple stresses, including climate change
225 [21]. It was reported by Vohland and Barry that rainwater harvesting supported sustainability
226 in the sub-Saharan Africa **which has been** facing climate change impacts [22].



Fig. 4: Roof for the collection of rainwater being blown by the cyclone PAM

It was reported that most of the Islands were flooded by the overflowing local rivers which intensified the damage to the supporting structures of the harvested systems. Being predominant volcanic formations with rich calcium carbonate deposits, the flood water weakened the structures by dissolving the crumbled bases due to the strong winds. Earlier it was a debate in sealing the bases of the rainwater harvesting systems to be sealed with cement base but, in most places the local practice of direct eruptions from the land are preferred. May be the idea would have saved many from the cyclone impact besides protection from the termite attack as well. It was learned that reasons behind the opposition was the thought that the mixing of other ingredients into the land would bring harm and as well spoil the fertility of the nearby areas as well. It seems that the idea had its advantages and concerns but, at the same time need more studies in finding the facts. Even the use of covering for the wooden bases with polyethylene or rubber sheets was not being practiced in many areas as they were against the custom practices. Sometimes the extra support from the cross fixing with other stands has been commendable and a sustainable practice being followed in other parts of the world but, at the time of instances like present would have no bearing for them at all.

Far away in the North with areas close to the coast and where the cyclone reached first had to face the impact directly and was the place of highest human loss as well. The villages with the harvesting systems were now seems to be past glory and require a mammoth effort in restoration as the transportation for these areas was completely damaged. In most of the villages in Vanuatu and Tuvalu there was damage due to the tangling of the electric wires with the community collection pipes. Most of the pipes were dragged down by the flown wires in all directions and the damage was escalated as they were down to pieces. Iririki Island in Vanuatu being with tourist resorts and a boat bay had been upside down due to the swirls which cut across the small piece of land after hitting the main Island. Here the semi modernized collection tanks and their accessories were seen floating on the seawater. Near

257 Mele bay the community head had called up for the alternatives for immediate water
258 requirements but couldn't succeed as there was conflict among the members regarding the
259 management of the community harvested system. It was understood that the opposition for
260 the modernization was a minority concern and the community head could go with the
261 majority. In Solomon Islands the impact to the community harvested systems was worth
262 noted as many structures were down with broken plastic tanks.

263
264 At the Emalus campus of the University of the South Pacific in Port Vila, the harvesting tanks
265 were torn to pieces being caught in the whirlpool. The largest collection point at the central
266 market in the Lini's highway developed cracks leaking the harvested water. It got away from
267 the sight of the cyclone with its unique structural assimilation in the center of the market
268 beneath the strong wooden roofs backed by concrete basement. It was learned that the
269 government had been soft corned by the cultural influence in the modernization of the public
270 harvesting systems. The help of various organizations from Australia, New Zealand and
271 China in bringing modernization to the harvested systems were welcomed by the
272 government but were mostly denied by the communities. The impact of community meetings
273 with the NGO representatives from the government's side in educating for sustainable
274 practices for withstanding natural calamities has been a positive approach in the region. But
275 the communities were of the strong feeling that their cultural heritage and association with
276 the natural resources might be taken for granted for the western interests. Forster felt that
277 the psyche of the Pacific region communities and people had still to be understood in detail
278 as their cultural diversifications are completely different from others [23].

279
280 It was in the expatriate areas of the Islands where the modernized systems with cement
281 tanks and thick iron roofs survived **the impact** and the damage was estimated to be very low.
282 In Vanuatu it was only around 7% and in Fiji with 2% to the harvested structures. The use of
283 the lengthy and strong nails along the approaches of the channels saved the day for the
284 systems here. Whereas the use of the palm and coconut wood bases with plastic **roofing**
285 doomed the day for most of the structures in the Pacific region. The integrated solar and
286 harvesting system sets in some of the areas of Malapoa had proved strength of mutual
287 windings and with support of each other in different directions. The same view being
288 reported by Chong et al., that the harvested prospects would be more in having a wind-solar
289 hybrid harvesting systems and would also stand as an environmentally sustainable practice
290 [24]. It was the same that observed in some villages where tanks backed by tree trunks
291 survived the **impact** leaving the channels being blown away. It seems that integration with
292 respect other sections of harvesting like downstream, backyards, gardening areas would
293 strengthen and increase the harvest rather than an isolated structures as **reported** by Wong
294 [25]. **The durability of the integrated systems** was comparatively higher and on the lighter
295 note at least some remnants shall be there after calamities, **proclaims** the community head in
296 Tanna Island.

297
298 Cowden et al., reported that the integration not only helps in financial obstacles but shall be
299 useful in the long and dry seasons as well [26]. The public and private partnership type of
300 constructions with the government's aid and expertise had made the difference in some
301 areas **of the region**. The commercial hub of Elluk in Vanuatu and Honiara, Capital of
302 Solomon Islands didn't suffered much as **those were** made with concrete structures besides
303 the compact shopping complexes. Pachpute et. al., observed that **the** rainwater harvesting
304 practices incorporating integrated approach had increased the productivity of collected water
305 besides durability [27]. It was understood that the political instability at times in the Pacific
306 region had been a major setback in bringing the update in technology. Earlier there were
307 several memorandums of mutual co-operations with countries like Australia, New Zealand,
308 China etc., but soon after the change in the government these seems be lost somewhere.

Also the lack of self-economic resources apart from strong tourism resources had always laid severe constraints on the development in the region.

Besides these the strong cultural heritage in the region had always dominated in setting the political agenda with a sole theme of continuing of cultural heritage rather than westernization. It was the same as observed by the father of the nation late Walter Lini but, he had also felt that there would be some good as well in westernization of the Pacific regions [28]. This had been the basic reason that most of the villages still use the feeding from the palm and coconut as the best for the harvested waters and consider the modern parts as perils. The recent encouragement of some of the governments of the Pacific in supplying the harvested equipment with subsidiary prices is a promising step towards the prospects of the future needs. In fact the Prime Minister of Vanuatu was even liberal in allocation of 20% of the provident fund to be used without any interest and ordered the banks to implement the same as well. But there was severe shortage of the material being observed due to lack of stocks by virtue of sudden huge demand. Again a conflict was raised as some of the communities had opposed imports of the materials and suggested to incorporate traditional usage in protecting the Pacific culture.

It seems that the Pacific region with substantial monsoon would require further strength in countering impacts with integrations from other structures rather than being damaged or with low output. Some of the newly built harvested systems at various schools with the integrated approach and modern equipment had withstood the impact and thus rendering to be the best possible model for these areas. The debate of culture vs modernization had always been a conflict as both had a win-win situation at given times but, it seems that the latter's stake would be more beneficial in these areas. But Mbilinyi et. al., reported that indigenous knowledge had been a decision support tool in rainwater harvesting [29]. It seems that the time had come in the region to review and propose a model which would be an integrated of cultural style with modern equipment. As the cyclone had exposed the weak links and strong bases in the existing harvested culture in the Pacific region, the new model should be a blend of these. It would also be taken care of the earlier resilience's before the policy and implementation would be drafted for the region. The open debate and wide consultations with the communities would certainly pave new era in the harvest in the region. Being a region of low communications among various Islands, time would be long enough to bring the consensus of the implementation of a methodology to be adopted by all.

May the introduction of new methodologies like the umbrella model or use of rain barrels etc. in collection of the harvested water should also be a part of the cultural transformation. Earlier in Tuvalu where severe agitation for the community harvested construction was raised by the local communities was later subsidized from the benefits of having long runs of the water availability. The increase in the academic pursuits in the Pacific region has been yielding the fruits for successful negotiations from the educated with the cultural heads in bringing up the modernization. Globalization might be very fast in some places but the Pacific it is a different place where change would be associated with time and patience. The views of introduction of these in the curriculum in the schools and colleges were thought by some governments but were withdrawn out of political pressures. Fiji which incorporates the Australian curriculum had been making progress in initiating sustainable practices and could reach the people in taking the advantages of the modernization. The introduction of environmental education in some of the French schools in the Pacific region was also commendable in this context. These signs are paving a better way in understanding the nature, the technological way and with the integration of the Pacific culture would yield better prospects for the future.

4. CONCLUSION

The category 5 cyclone, Pam was a nightmare as the trauma continues for those who witnessed and shall render in only way, 'survived' but don't know how. The damage to their cultural rainwater harvesting systems was at the highest order as the gale winds had blown away everything. There were some remnants in the expatriate areas to identify as they belong to the rainwater harvesting but no traces were left in the villages. The extent of damage was significant of the fact that the systems here were being built of casual strength as if they were being temporary. The stands of palm and coconut with plastic for the roofs and channels were ecofriendly but are too weak to sustain any impacts. They might be based on the idea for being the best models to counter earth quakes in the region but, these harvesting systems are vulnerable on all other instances. It was obvious that the intensity would vanish anything but modernization might have reduced the impact but it was against to the pacific culture. The blessing in the disguise was that the cyclone had raised the debate for sustainable practice in the Pacific region. The conflict of tradition vs modernization of these systems lays here until really something must change. Nevertheless, the encouragement from the governments in the Pacific region for sustainable practices is a promising step in seeing the prospects of harvested systems would sustain future global changes.

CONSENT

"The author declares that 'written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office/chief editor/editorial board members of this journal."

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