

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, 2016.

Methodology: The study was based on the field observations; estimates from authenticated sources with the evidence of the pictorial data as these include the collection from the 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 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 the bringing a drastic change for sustainable practices in withstanding global changes. May be an integrated model with traditional look 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. According to United Nations [2], the climate-change impacts 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 management of 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 observed it as a time-honored practice since ages [5].

According to Hunt's observations in Kiribati and Tuvalu countries of the Pacific region that 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 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 is preventing many communities in the Pacific Islands to favor traditional methods [8]. He further felt that the political uncertainty in the 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 is seen not only confined to rainwater harvesting but in all aspects of the life style in the Pacific region. May be time with need shall decide the fate of systems as already scarcity for the growing population is evident in most of the Pacific regions. White et. al., felt that there were many limitations in the use and storage of harvested rainwater in Kiribati of the Pacific region [9].

But in the Pacific region, rainwater harvesting is considered as a mandatory set up in civil planning and has been accepted widely at both public and private places as many other places in the world as observed by Kim [10]. Stockholm Environment Institute (SEI) [11] refers the practice as a blessing from the sky whereas, according to Conserve Energy Future (CEF) is keen in displaying 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 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. The cultural practice along with modernized review in harvesting besides a note on the challenges in the region was also considered in the evaluation. The government had taken steps in educating the role of modernization in countering damage in all fronts like construction, infrastructure, materials, expertise etc.

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 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 based on the strong cultural impact of being with nature. People consider drinking rainwater is more pious than any other form of water as they consider it the other form of God. It is 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 that the cultural practices sometimes are the most environmentally friendly strategy in rainwater

harvesting [15]. It was prevailing here that that being a part from the cave culture to collect the water from outside, people used ditches on the ground on the plains. The reason harvested water being given importance over the agriculture than drinking is the constant monsoon and shortage for freshwater resources in these areas. Now being a part of the modernization cement and plastic tanks with perfect roof channeling were being implemented for the most output. The increased harvesting culture here had the reason of the development of the intrusion of the saline water from time to time and being the Islands this problem was ever persisting. It was also due to the development and disappearance of the lagoons with seasonal fluctuations.

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

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

2. METHODOLOGY

The study was based on the extent of damage to the traditional rainwater harvesting systems by the cyclone, both on the quality and quantity. The base of the study was at the capital of Vanuatu, Port Vila and extended to the other Islands. Reports from the nearby Island countries like New Caledonia, Solomon Islands, Fiji and Tuvalu were considered in the evaluation of the impact (Fig. 1). The estimate was authenticated from some sources with the evidence of the pictorial data as these include the collection from the remote areas without any communication facilities. The study was effective as it was done the next day from the impact and could gauge the damage as it stands. The views of individuals, community heads, government bodies and relief workers of various national and international agencies were integral part of this assessment.

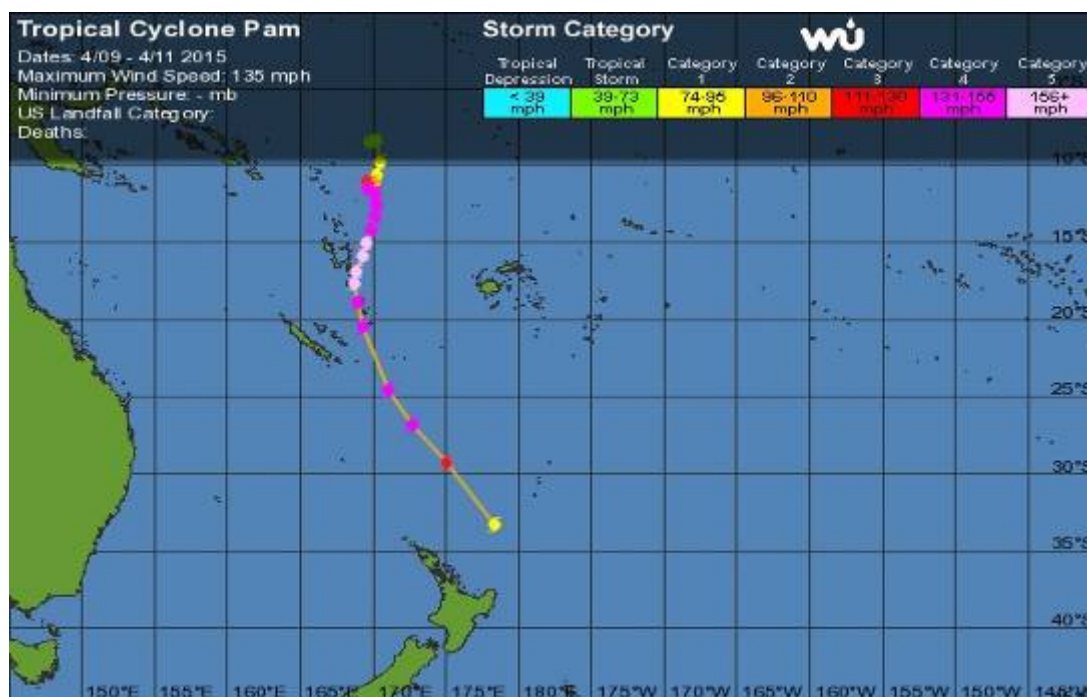


Fig. 1: Satellite image of the Pacific region Cyclone Pam

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

3. RESULTS AND DISCUSSION

The cyclone PAM was a category 5 type and was considered a monstrous one that left most of the Pacific region countries devastated. It started at latitude of -8.5 and longitude of 169.8 and crossed the bay at -33 and 178.3 in the Pacific region (Fig.1). With whirlpool winds over 250 Km/h uprooted gigantic trees and seen them flown like cotton fibers. Port Vila, the capital of Vanuatu being in the eye of the cyclone had the destruction at its highest order (Fig.2). Being pitch dark and unbearable whistles of the wind squirrels with heavy rain, it was a nightmare. The inner vision from the sounds of the flying roofs and collapses thought that one should never get off from their position and shall remain stand still. It would be nothing sort of a hell for the children in to be covered under the fiber boats all night. It was a night where a single thought of 'survival' being prevailed all over the Pacific region. The Asian Development Bank had estimated that more than 50 million dollars of loss and damage occurred to the infrastructure besides personal and human loss. The UNO pronounced it as the loss of unprecedented extent and would take decades to be refilled for the tiny Island nations. It was preliminary report 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.

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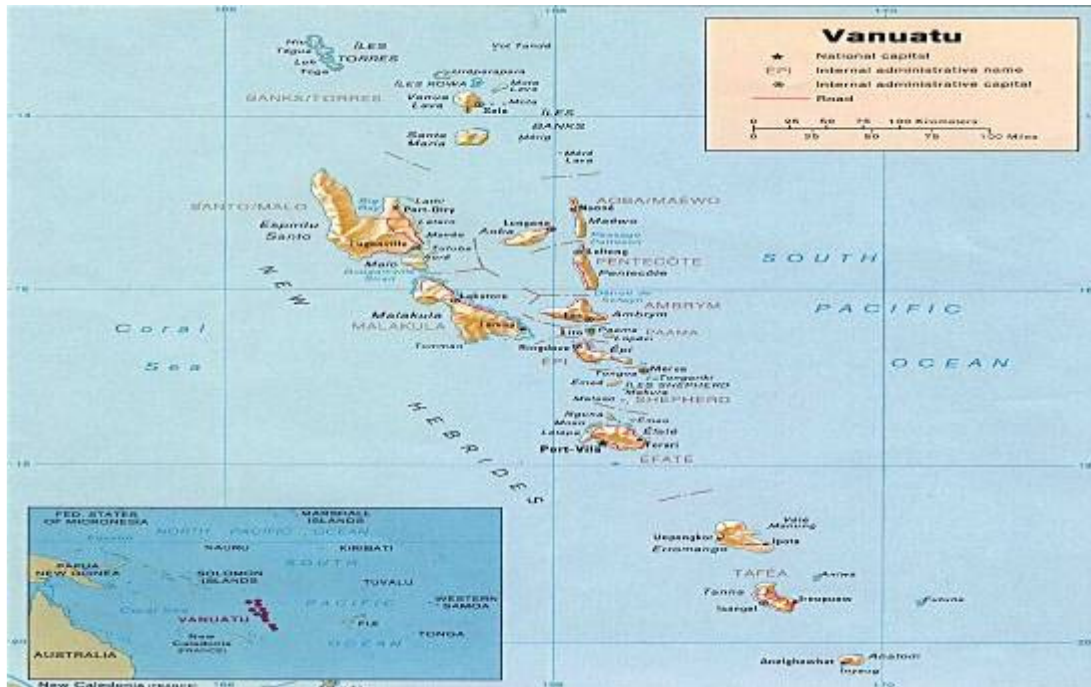


Fig. 2: Map of Vanuatu and other Island Countries

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The magnitude of the damage was evident in the daylight as everything was down with the devastation. The survey of 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 of the study area under examination. The average of the village's damage was around 62%. Tanna of Vanuatu recorded a maximum of 92% damage to its rainwater harvesting systems and Suva capital of Fiji Islands with a least of 18%. In Honiara of Solomon Islands at extent of 57% was recorded. In Tuvalu and New Caledonia countries the damage was around 43% and Fiji with the least of 32% were being assessed from the reported data. The damage being varied with the cyclone changing its direction without predictions and speed and most of the preparatory arrangements were indeed in vain in most of the places. It was reported that there would be a category 3 cyclones at the most but it had crossed the expectations of the Joint Typhoon Warning Center (JTWC) and recorded as 5 and the major reason being the sudden depression formed in the South Pacific Ocean. The misgauge in the warning had some serious impact in 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 to the tree tops was clear report of the gale winds and the poor harvested systems main parts were now being collected from the debris. On the other parts 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 ruined completely and others were damaged to an extent. The extent of preparatory arrangements made the difference from case to case besides the approach in construction from the government expertise in some parts had saved the day for many. The harvesting structures were being down by the collapsed coconut trees (Fig. 3) in the Northern parts of the Island nation. Earlier the same trees were excellent sources of rainwater and protected from mild to strong winds, but they were the culprits this time around. The context coincided with Evans et al., observation that even though rainwater harvesting is an environmentally sustainable practice but at times the environmental factors do magnify the unwanted natural impacts as well [20]. It was learnt that the change in the direction of the wind after early hours doomed them. It was recorded that in most of the villages no traces of the systems were observed and especially it was very severe in Mare in the New Caledonia as well as Asau in Tuvalu. The NGO's of Australia are busy in

195 rebuilding the community harvested systems and learnt that they would be ready by the end of the
196 year.



Fig. 3: A community collection center being damaged by the cyclone PAM

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200 It was evident from the sites that the thin iron roofs and the plastic pipes never gave any resilience at
201 any point and obvious at the power of the monstrous cyclone. It was a common picture around these
202 countries where many of the houses were left with roof (Fig. 4). Especially areas which were on the
203 hill tops like Erkor Mountain suffered the most. Alternative water source from the rivers in absence of
204 harvested rainwater was hampered by the intrusion of salt water from the nearby lagoons. In many
205 places the roofs and channels were seen flowing through the overflowing rivers. The recovery was
206 poor as of the plastic being done to bit and pieces due to the flow rate. Most of the bays were seen
207 heaped with the roofing material, channels and torn plastic tanks of the harvested systems. It was a
208 pathetic that neither the collection systems nor the utensils were left though there was sufficient rain
209 for days after the cyclone. They were forced against their culture to have the bottled water and they
210 had for the mere survival. In view of these cultural jinxes all over the world Hay and Nobuo felt that,
211 development can be made more sustainable by increasing the ability of systems and societies to adapt
212 to multiple stresses, including climate change [21]. It was reported by Vohland and Barry that
213 rainwater harvesting supported sustainability in the sub-Saharan Africa facing climate change impacts
214 [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 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 the idea would had saved many from the cyclone impact besides protection from the termite attack as well. It was learned 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 at the same time and 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 is commendable and a sustainable practice being followed in other parts of the world but instances like these 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 of past 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 to their breakdown into pieces. Iririki in Vanuatu being an isolated Island 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. The community head had called up for the alternatives for immediate water requirements but couldn't succeed as there was conflict among the members regarding the management of the community harvested system. It was understood that the opposition for the modernization was a minority concern

244 and the community head could go with the majority. In Solomon Islands the impact to the community
245 harvested systems was worth noted as many structures were down with broken plastic tanks.
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247 At the Emalus campus of the University of the South Pacific in Port Vila, the harvesting tanks were
248 torn to pieces being caught in the whirlpool. The largest collection point at the central market in the
249 Lini's highway developed cracks leaking the harvested water. It got away from the sight of the
250 cyclone with its unique structural assimilation in the center of the market beneath the strong wooden
251 roofs backed by concrete basement. It was learned that the government had been soft corned by the
252 cultural influence in the modernization of the public harvesting systems. The help of various
253 organizations from Australia, New Zealand and China in bringing modernization to the harvested
254 systems were welcomed by the government but were mostly denied by the communities. The impact
255 of community meetings with the NGO representatives from the government's side in educating for
256 sustainable practices for withstanding natural calamities has been a positive approach in the region.
257 But the communities were of the strong feeling that their cultural heritage and association with the
258 natural resources might be taken for granted for the western interests. Forster felt that the psyche of
259 the Pacific region communities and people had still to be understood in detail as their cultural
260 diversifications are completely different from others [23].
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262 It was in the expatriate areas of the Islands where the modernized systems with cement tanks and
263 thick iron roofs survived and the damage was estimated to be very low. In Vanuatu it was only around
264 7% and in Fiji with 4% to the harvested structures. The use of the lengthy and strong nails along the
265 approaches of the channels saved the day for parts of the systems here. Whereas the use of the palm
266 and coconut wood bases with plastic roofing's doomed the day for most of the structures in the Pacific
267 region. The integrated solar and harvesting system sets in some of the areas of Malapoa had proved
268 strength of mutual windings and with support of each other in different directions. The same view
269 being reported by Chong et al., that the harvested prospects would be more in having a wind-solar
270 hybrid harvesting systems and would also stand as an environmentally sustainable practice [24]. It
271 was the same that observed in some villages where tanks backed by tree trunks survived the day
272 leaving the channels being blown away. It seems that integration with respect other sections of
273 harvesting like downstream, backyards, gardening areas would strengthen and increase the harvest
274 rather than an isolated structures as earlier observed by Wong [25]. These integrated systems
275 durability was comparatively higher and on the lighter note at least some remnants shall be there after
276 calamities claims the community head.
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278 Cowden et al., reported that the integration not only helps in financial obstacles but shall be useful in
279 the long and dry seasons as well [26]. The public and private partnership type of constructions with
280 the government's aid and expertise had made the difference in some areas. The commercial hub of
281 Elluk in Vanuatu and Honiara, Capital of Solomon Islands didn't suffered much as may are made with
282 concrete structures besides the compact shopping complexes were able to withstand the cyclone
283 effect. Pachpute et. al., observed that rainwater harvesting practices incorporating integrated approach
284 had increased the productivity of collected water besides durability [27]. It was understood that the
285 political instability at times in the Pacific region had been a major setback in bringing the update in
286 technology. Earlier there were several memorandums of mutual co-operations with countries like
287 Australia, New Zealand, China etc., but soon after the change in the government these seems be lost
288 somewhere. Also the lack of self-economic resources apart from strong tourism resources had always
289 laid severe constrains on the development.
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291 Besides these the strong cultural heritage in the region had always dominated in setting the political
292 agenda which has been predominant in survival of the culture rather than intrusion of western culture.
293 This had been the basic reason that most of the villages still use the feeding from the palm and
294 coconut as the best for the harvested waters and other modern parts are considered as perils. It was
295 same as observed by the father of the nation late Walter Lini but, he had also felt that there would be
296 some good as well in westernization of the Pacific regions [28]. The recent encouragement of some of

the governments in issuing 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 was observed due to lack of stocks. Again a conflict was raised as some of the communities had raised their voice against import of the materials and suggested to incorporate traditional usage in protecting the Pacific culture.

It seems 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 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 many times but it seems that the latter's stake would be more beneficial in these cases. 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.

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 but was later subsidized from the benefits of having long runs of the water availability. The increase in the academics in the Pacific region is yielding the fruits for successful negotiations from the educated with the cultural heads in bringing modernization. Globalization might be very fast in some places but the Pacific 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 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 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 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 at all other instances. It was obvious that the intensity would vanish anything but modernization might have reduced the impact but was against to the pacific culture. The blessing in the disguise is 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.

350 **CONSENT**

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

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