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“Listening to fellow Environmental Leaders, it becomes immediately clear that we are lagging behind...”

CONTENTS

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Journal of Caribbean Environmental Sciences and Renewable Energy

MARINE ECOSYSTEMS & FISHERIES

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MARINE ECOSYSTEMS & FISHERIES

Change in Length and Weight of *Holothuria mexicana* Sea Cucumber During Processing

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ABSTRACT

Knowing the conversion ratio of processed sea cucumbers is important in determining the amount harvested from the wild. In Belize, the sea cucumber fishery was opened from 2009-2016. Estimating the amount harvested from the wild was especially difficult since sea cucumbers were exported semi-processed or dried. Dry weights were used to estimate the catch, yet the total allowable catch (TAC) was set based on wet weight. In this study, sea cucumbers were collected monthly for eight months and processed. The largest and heaviest individuals came from Marine Protected Areas (MPAs) and were found during the reproductive months. On average individuals lost about 54% of their total length and 84% of their body weight. The majority (87%) of all the processed sea cucumbers were of inferior quality. Sea cucumber exporters and fishers need more training in sea cucumber processing.

INTRODUCTION

Countries that recently created or are about to create a sea cucumber fishery have much to learn about the commercial aspects of the fishery, including the market, prices, commercial policies, marketing and quality of the product. Such information was needed in Belize before permitting a sea cucumber fishery. The sea cucumber fishery in Belize was formally opened from 2009-2016 although sea cucumbers had been fished in the previous 20 years **[1]**. Although a total allowable catch (TAC) based on wet weight was set annually, there was no mechanism in place to determine how much catch was extracted from the wild by sea cucumber fishers. This was primarily because sea cucumbers were exported semi-processed or dried and these export data were used as a total to estimate the TAC, yet the TAC was set based on wet weight.**[1]** Data on the weights of processed sea cucumbers for export or results of studies that use fishery-dependent surveys are obtained with great difficulty and errors as they can be in various processing stages at the time such information is obtained.**[2]**

The processing of sea cucumbers has a major influence on price **[3]**,**[4]**, especially for sea cucumber exporters. Any fault in the process risks the quality of the end product.**[5]** The commercial value of a species is determined by the size and the thickness of the body wall **[6]**, and the species itself.**[7]** While the dry weight to wet weight conversion ratios of processed sea cucumbers have been studied for various species in New Caledonia **[6]**,**[2]**, Tonga **[8]**, and Madagascar **[9]**, to our knowledge no such study exists in Latin America or the Caribbean for the harvested species *Holothuria mexicana*. At the request of the Belize Fisheries Department (BFD), this study was completed with the aim of providing a conversion ratio for each processing stage, especially for semi-

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processed and dry sea cucumbers, the two export stages. These results can be useful to determine the amounts harvested from the wild and to monitor the TAC.

METHODOLOGY

Around 28-30 *H. mexicana* individuals were collected monthly from February to September 2015 during a study that looked at the reproductive cycle of *H. mexicana*.**[10]** This resulted in a total of 232 individuals. Collection sites were all in Southern Belize (Fig. 1).

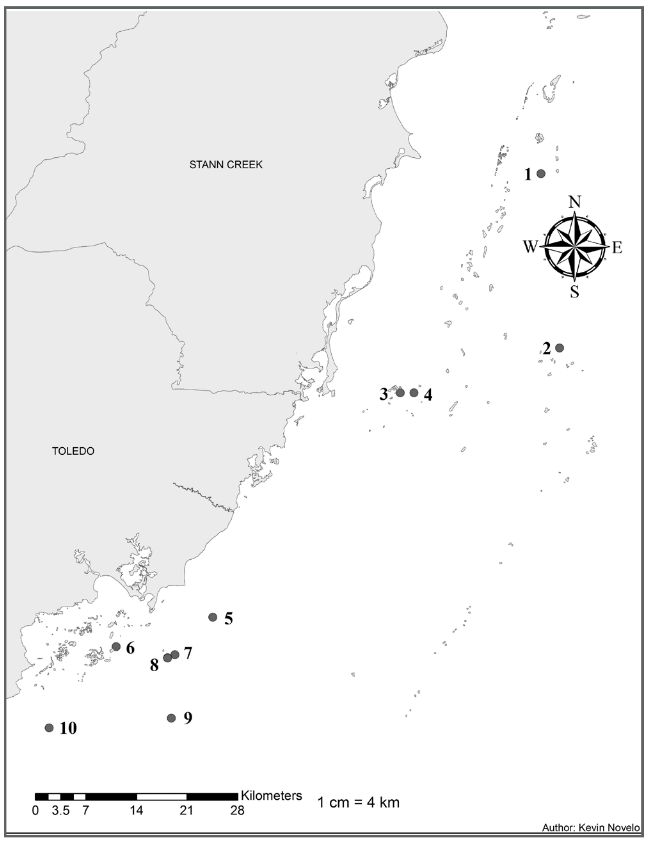

Figure 1. Sea cucumber collection sites in southern Belize including 1 Tobacco; 2 Gladden; 3 & 4 West Laughing Bird; 5 Tarpon and Abalone; 6 The Range; 7 & 8 Snake Cayes; 9 Southeast PHMR; 10 Southwest PHMR. All

All individuals were processed through 10 stages (Table 1 and Fig. 2). In all stages, all individuals were treated similarly to the way that fishermen and sea cucumber exporters treat them for processing and export. All individuals were processed at a sea cucumber processing plant in the Boom Road in the Belize District. Each stage was coded (Table 1). Each individual was collected, total length (1L) measured in situ (Fig. 2A), eviscerated and then weighed (Fig. 2 B, C, D). Total weight and total length were regarded as the weight and length of the drained body wall plus the drained viscera and drained gonads (1W) which were weighed separately (Fig. 2 C). The length (2L) and weight of the body wall (2W) were also recorded. All individuals were individually labelled, transported to the laboratory at the University of Belize and frozen (Fig. 2 E).

This is similar to what fishermen do after they land their sea cucumber catch in late evenings and there is no exporter available to purchase their catch. The following day, all individuals frozen lengths (3L) and weights (3W) were taken, corresponding to when fishers sell frozen sea cucumbers). Subsequently, all individuals were thawed (Fig. 2 F), measured (4L) and weighed (4W) again. Sea cucumbers were then boiled (Fig. 2 G) for an hour and cooled; measured (5L) and weighed (5W); placed in containers with brine (Fig. 2 H) and left for 2 days after which they were measured (6L) and weighed (6L) again. Some exporters dry freeze and export them at this semi-processed stage.

The sea cucumbers were then sun-dried for 8 days (Fig. 2 I), measured (7L) and weighed again (7W). At the end of the eight days, the individuals were re-boiled for 1 hour (Fig. 2 J), measured (8W) and weighed (8W) again. They were then sun-dried again; lengths and weights taken at day 15 (9L and 9W; Fig. 2 K) and day 30 (10L and 10W; Fig. 2 L). At day thirty of sun drying, the specimens were considered to be fully dried (bêche-de-mer) Some exporters export them at this stage.

Table 1. H. mexicana bêche-de-mer processing stage names and codes

Stage	Code (Weight)	Code (Length)
Total Weight	1W	1L
Body Wall Weight	2W	2L
Frozen Weight	3W	3L
Thawed	4W	4L
1st Boil (Semi-Processed)	5W	5L
2 days brine	6W	6L
8 days sun dry	7W	7L
2nd boil	8W	8L
15 days sun dry	9W	9L
30 days sun dry	10W	10L

Fig 2. A Obtaining total length in situ; B Evisceration; C Gonads drained and weighed separately; D Weighing body wall; E Tagged and bagged sea cucumbers for freezing; F Thawing; G First boil; H Brining; I Sun drying; J Second boil; K Sun drying for 15 days; L Sun drying after 30 days (bêche-de-mer).

RESULTS AND DISCUSSION

Length and Weight Lost

For this study, the initial mean total length per month ranged from 20.9 – 36.9 cm and varied across sites (ANOVA: $P < 0.001$), similar to the mean total length obtained for the reproductive study which varied across sites and habitats.[10] The initial mean total weight per month ranged from 354 g – 841g and varied across sites and habitats. These heavy individuals had a moderate correlation to the range of large individuals (scatterplot, R^2=0.58); not all individuals that were heavy were large. During processing, all individuals decreased in length in all stages, except 6L when they were slightly hydrated after the second boil (Table 2).

Table 2. Mean Length (cm) for each processing stage by month

Month	1L	2L	3L	4L	5L	6L	7L	8L	9L	10L
Feb	21	19	19	16	13	13	12	13	11	11
Mar	23	22	21	21	18	17	16	17	15	14
Apr	27	25	26	17	14	13	11	12	11	10
May	28	27	27	21	17	17	14	15	13	13
Jun	28	26	24	20	17	18	16	16	14	13
Jul	27	26	24	22	16	17	15	15	13	12
Aug	37	35	34	24	18	19	17	17	14	13
Sep	30	29	28	23	18	17	16	16	14	13
Avg	28	26	25	20	16	16	15	15	13	12

In stage 2W, the mean weight did not change after individuals were thawed except for the month of February that shows a decrease in mean weight (Table 3) which may have been due to loss in water after individuals were thawed. In all subsequent stages, individuals decreased in weight, except in 6W when they were slightly hydrated after the second boil (Table 3).

Table 3. Mean Weight (g) for each Processing Stage by Month

Month	1W	2W	3W	4W	5W	6W	7W	8W	9W	10W
Feb	360	257	260	246	116	103	108	121	79	76
Mar	581	433	435	407	206	182	191	254	138	134
Apr	354	264	268	233	116	105	108	142	79	75
May	807	626	628	595	279	259	165	209	133	92
Jun	688	529	530	525	291	256	173	185	109	91
Jul	589	451	452	436	220	204	137	139	83	72
Aug	841	665	667	459	244	277	199	200	118	99
Sep	615	476	479	342	186	214	149	151	89	75

The average total length of individuals decreased by 5% (Figure 3, 2L) and weight by 24% (Figure 4, 2W) after evisceration. After freezing, the total length decreased by 8% (Figure 3, 3L) and weight by 24% (Figure 4, 3W). Following the 1st boil, the total length decreased by 39% (Figure 3, 5L) and weight by 66% (Figure 4, 5W). After the final stage of sun drying for 30 days, the total length of individuals decreased by 54% (Figure 3, 10L) and weight by 84% (Figure 4, 10W).

Fishermen usually sell fresh or frozen catch based on weight and not by number of individuals or length. While a difference was observed between the wet weight and the frozen weight, this difference was small (0.4%) and thus would not affect the price to fishers for their frozen catch when compared to their fresh catch.

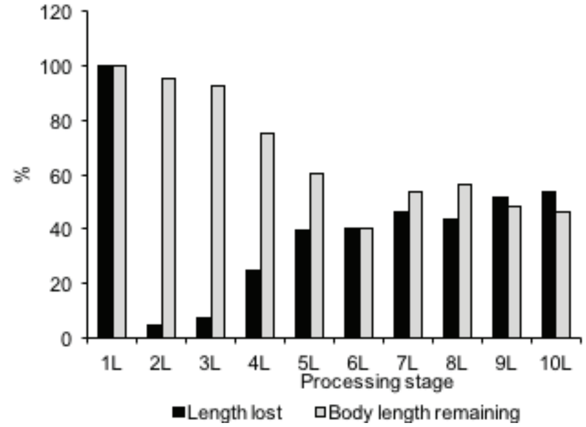

Figure 3. Percent water lost and body length in each H. mexicana processing stage

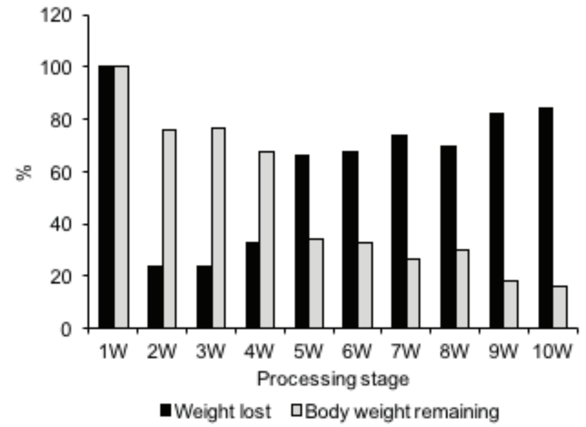

Figure 4. Percent water lost and body weight in each H. mexicana processing stage

Conversion ratio

From the data derived at various processing stages conversion ratios for each stage based on length (Table 4) and weight (Table 5) were calculated from the average data for all months.

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The Journal of Caribbean Environmental Sciences and Renewable Energy
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Table 4. Percent change in length of Holothuria mexicana after each processing stage.

	1L	2L	3L	2L	1L	2L	1L	2L	1L	2L
Mean	28	26	25	20	16	16	15	15	13	12
Conversion Ratio	N/A	94.9	92.2	74.1	59.6	59.1	53	55.4	47.1	45.3

Table 5. Percent change in weight of Holothuria mexicana after each processing stage.

	1L	2L	3L	2L	1L	2L	1L	2L	1L	2L
Mean	605	26	25	20	16	16	15	15	13	12
Conversion Ratio	N/A	94.9	92.2	74.1	59.6	59.1	53	55.4	47.1	45.3

*The conversion ratio was derived by dividing the mean length from the current stage by the original total weight or total length and multiplying the quotient by 100.

Weight relationship with spawning months

While fishers suggested that *H. mexicana* body wall weight (2W) seemed to increase during spawning months, there are no studies that look at such correlation. It is noted [1] that there was a positive relationship between total length and total weight for all individuals, regardless of where they were collected relative to marine protected areas. In this study, the results of random scatter of the body wall length-weight (2L and 2W) relationship by month showed that the residuals didn't contradict the linear assumption; suggesting that most of heavy individuals were normally larger and were not heavy because they were in their reproductive season. Although some of the shorter individuals (~32 cm) were among the heaviest (~800 g). Individuals were heavier (1W) during the reproductive months because their gonads were heavier [11]. The total wet weight (1W) and body wall weight (2W) of individuals varied significantly among months (ANOVA: $p < 0.001$). The heaviest individuals (total wet weight) were found in the months of May (avg. 807 g) and August (avg. 841 g). Relatively heavy individuals were also found in March (avg. 581 g), June (avg. 688 g), July (avg. 589 g) and September (avg. 615 g) (Tukey SD, $P < 0.05$); all these months correspond with the reproductive months of *H. mexicana* in Belize [10]. Peak spawning months were from April - May and July - August [10].

Bêche-de-mer quality

Bêche-de-mer quality requirements are widely accepted as processed sea cucumbers that are larger in size (12 cm and above), clean and free from sand or dirt or white salty deposits, have a straight cylindrical form, are dark in colour (instead of light in colour), have no odour and are thoroughly dry [12] . Based on these criteria, the results of this study, yielded (as guided by the sea cucumber exporter) only 13% of individuals with good bêche-de-mer quality (Figure 5 A, B, C and D). Bêche-de-mer quality is a direct result of its processing, not based on the individual sea cucumber characteristics (except large size and dark colour which are favoured). Although these were considered to have "good" quality, they were still not of the highest quality. For instance, they had visible layers of salt and mud on the surface and the incision made for evisceration was visible (Figure 5 B). The majority (87%) of the individuals processed had inferior quality (Figure 5 E, F, G and H). These individuals had either one or more than one inferior quality features such as having a layer of mud, too much salt, had a large cavity or had irregular shape. Although the size is the major factor in attaining

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Vol. 2, Issue 1, (2019) doi.org/10.33277/cesare/002.001/01

quality status, there are other factors such as shape, size of cavity, presence of foreign matter on body wall such as mud or sand, and extent of drying that dictate the price that is ultimately offered for the bêche-de-mer.

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These quality features were affected in various ways. For instance, each fisher had a way of gutting sea cucumbers. This was usually dependent on whether a small or a large incision for evisceration was the easiest evisceration method for them or based on the incision type the exporters asked them to do. Some sea cucumber fishers would make a small incision on the ventral body and others would make one large incision on the ventral body (Figure 5 F). Others would make two small incisions on both anterior and posterior ends of the ventral body (Figure 5 D), During processing, if not set to dry on a flat surface the sea cucumbers will not acquire the desired flat shape (Figure 5 E and G). Knowing the percent of salt needed to dehydrate is important so that large amounts of salt don't accumulate on the surface. All these factors play a role on the amount of money that the exporters are offered. Exporters expressed their preference for exporting semi-processed sea cucumbers since the market demanded high-quality sea cucumbers they weren't able to provide. The reason for the price difference is that Asian markets have an affinity for products that are visually appealing and that stay appealing after they are prepared.**[13]**

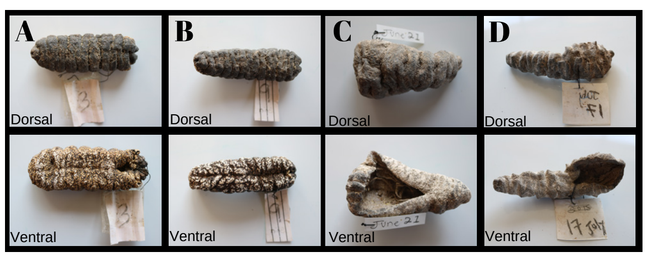

Figure 5. A, B, C, D Good quality Bêche-de-mer (A and C Dorsal; B and D Ventral); E, F, G, H Inferior quality bêche-de-mer (E and G Dorsal; F and H Ventral)

CONCLUSIONS AND RECOMMENDATIONS

The percent of water lost during each processing stage can be very valuable when illegal processed sea cucumbers are seized to determine processed stage and wet weight. This information may also be useful for those countries that commercially harvest or plan to harvest *H. mexicana*. This study is the first to produce information for *Holothuria mexicana* from wet weight to bêche-de-mer. The results of this study were aimed to represent the average weight loss for this species during processing and to facilitate the management of this fishery. It is recommended that similar studies are completed for all months and body wall weight compared with reproductive months based on a larger sample size. Further replicate studies conducted at different locations around the coast of Belize would provide a more complete view of the populations of *Holothuria mexicana* in Belize. A sea cucumber guide that discusses sea cucumber biology, ecology, commercial value, processing and quality could prove useful to countries in this region. Training oriented to fishermen and exporters would benefit the industry by increasing the quality of semi-processed and dry sea cucumber.

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The Journal of Caribbean Environmental Sciences and Renewable Energy
Vol. 2, Issue 1, (2019) doi.org/10.33277/cesare/002.001/01

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ALTERNATIVE ENERGY & INDUSTRY

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A Review of Fault Monitoring for Utility-scale Solar Arrays

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ABSTRACT

As the solar energy output of the Caribbean grows, so does its need for proper maintenance of such systems. Solar modules degrade with time, and with this degradation comes a loss in their electrical performance. Solar module performance is also affected by common problems such as: manufacturer defects, adverse weather, and accidental damage. Thus, in order for a PV plant to maintain its capacity factor, the plant personnel must regularly inspect and maintain the array to ensure that anything detrimental to their performance is identified and rectified. This paper seeks to provide insight into the maintenance and inspection processes used by local and regional photovoltaic (PV) operators. These insights include the current methods that local PV operators use for fault inspection and maintenance. The effectiveness of these methods will be investigated and the way these methods could be improved will be explored. The inspection and maintenance techniques will also be compared to the current global standards, to determine whether local PV projects are operating competitively in an international context. Additionally, this paper will explore current trends and innovative methods of inspection, such as thermographic imaging for fault detection and the use Unmanned Aerial Systems (UAS) for automated/semi-automated inspection. The cost-effectiveness and value proposition these innovative systems have to offer will also be analyzed to empirically determine what local PV operators stand to gain if these systems were developed and adopted.

INTRODUCTION

Large-scale photovoltaic (PV) plants consist of an array of thousands of modules for smaller farms or hundreds of thousands for larger plants. For example, Content Solar, Jamaica's first and only utility-scale solar farm has around 91,000 modules and produces 20 MW of power [1]. This makes it one of the largest solar farms in the Caribbean, however, globally, this is on the smaller side of the spectrum. One of the largest single-site solar project in the world has over 2 million modules [2]. For a PV plant to maintain a high capacity factor, maintenance is paramount. However, proper maintenance is difficult partly due to the vast number of modules that must be individually inspected to ensure that each is operating as it should. There are also several complications with PV maintenance as the modules are relatively vulnerable. The semiconductor material of the solar cells degrades over time, electrical faults, internal or external to the module, can cause moderate to severe damage to the modules themselves, and they are susceptible to a variety of environmental impacts: soiling due to dirt in the wind and local animals (e.g. birds), expansion and contraction due to changing temperatures, and impacts from stray projectiles (e.g. stones from mowing grass, debris in high winds) [3].

PV array maintenance is difficult, and time consuming for very large arrays, but it is a repetitive task, thus automation can be a great boon to the issue of maintenance. This paper aims to highlight the ways in which automation can help streamline the PV maintenance

A Review of Fault Monitoring for Utility-scale Solar Arrays
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The Journal of Caribbean Environmental Sciences and Renewable Energy
Vol. 2, Issue 1, (2019) doi.org/10.33277/cesare/002.001/02

process by reducing the overhead required for the operation. There are several new, as well as, upcoming utility scale PV projects in the Caribbean that can benefit from such systems. Some of these plants are listed below in Table 1 [1] [4] [5].

Table 1: List of some major Utility Scale PV Projects in the Caribbean

Plant	Country	Current Installed Capacity (MW)	Year / Expected Year of Commission
Monte Plata	Dominican Republic	60	2016
Paradise Park	Jamaica	51	2019
Content Solar	Jamaica	20	2016
LUCELEC Solar Farm	St. Lucia	3	2018

PV Module Faults

As stated previously, utility scale PV arrays have vast amounts of modules. The large number of modules means there are many possible points of failure, i.e. system faults, associated with the arrays of the solar modules. Additionally, solar modules consist of several solar cells connected in series. Thus, a fault in just one cell can have a domino effect, impacting the power produced by the module by affecting the entire string of cells.

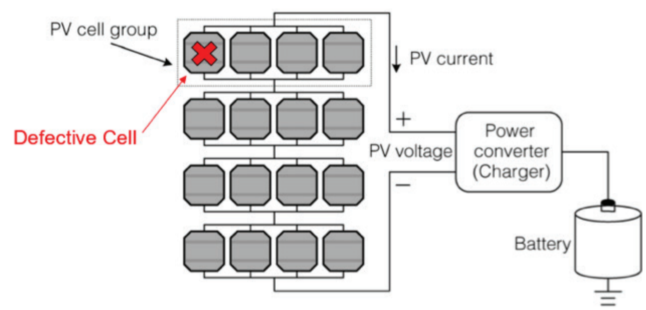

Figure 1: Schematic PV Module System Diagram with a defective cell. Adapted from Lin et al. (2014)

In their paper, Lin et al. (2014), state that even though only one cell in the cell array of 16 is defective, the total power output of the array is reduced by 16.5 %. This is because the system cannot perform optimally while a cell is defective. This emphasizes the vulnerability of PV modules to power output reduction due to faults.
PV arrays are comprised of PV modules. These modules are connected in series-parallel arrangements to optimize their power output, to provide energy to the grid. Each of these modules are a part of a string, and each of the modules is subject to faults. A PV module fault is defined as any failure or defect that affects the performance of the module. Faults can affect every part of the module or the array, so they can be categorized as such: semiconductor material, encapsulation, internal wiring, frame and mounting faults [6]. Some typical faults that occur in PV modules are laid out in Table 2.

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Vol. 2, Issue 1, (2019) doi.org/10.33277/cesare/002.001/02

Table 2: Typical PV Module Faults. (Rycroft 2016)

Fault Type	Observation	Current Installed Capacity
Semiconductor Material	Cracks in semi-conductor material, snail trails, etc.	These types of faults are generally due to a breakdown in the semi-conductor material that constitutes the PV cell.
Paradise Park	Discoloured or opaque cells	Degradation of the encapsulant
Internal Wiring	Broken or burned bus bars	Cell/module over current

2.1 Fault Detection

System faults directly affect the efficiency of the plant, and as such affect power output and thus the profitability of the plant. System maintenance is important and on-site engineers are required to detect faults and address maintenance issues. Faults can be detected using a SCADA (Supervisory Control and Data Acquisition) system, as these systems monitor the power output at various stages throughout in electricity generation and transmission sections of the plant [7]. SCADA systems, however, are generally not suited for detecting faults on the smaller scale i.e. on the module to module level. For these minor faults to be detected, the individual modules must be investigated.

2.2 Thermographic Imaging

Thermographic imaging of the modules is sometimes used to individually investigate the modules in order to detect faults. This is because most solar module faults affect the current flow through cells/modules. An increase in current flow, causes more heat to be generated, and thus the anomaly can be seen clearly through thermographic imaging. This is what makes thermographic imaging so effective for solar module fault detection. A fault that is undetectable by regular imaging becomes easily seen by thermographic imaging.

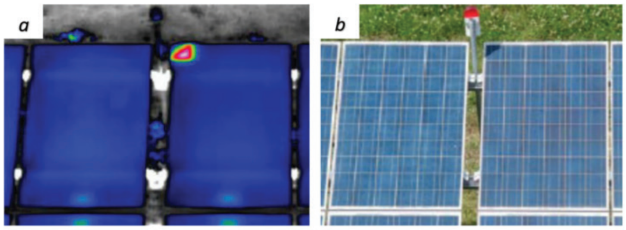

Figure 2: Representation of solar modules using a) a thermographic image of a partially shaded module and b) an image of a partially shaded module (upper left-hand corner). Adapted from VATH (2016).[8]

Figure 2 shows a comparison between a regular image of a shaded module and the thermographic equivalent. What looks like very minor shading in the regular image, is seen as a very bright hotspot in the thermographic image.

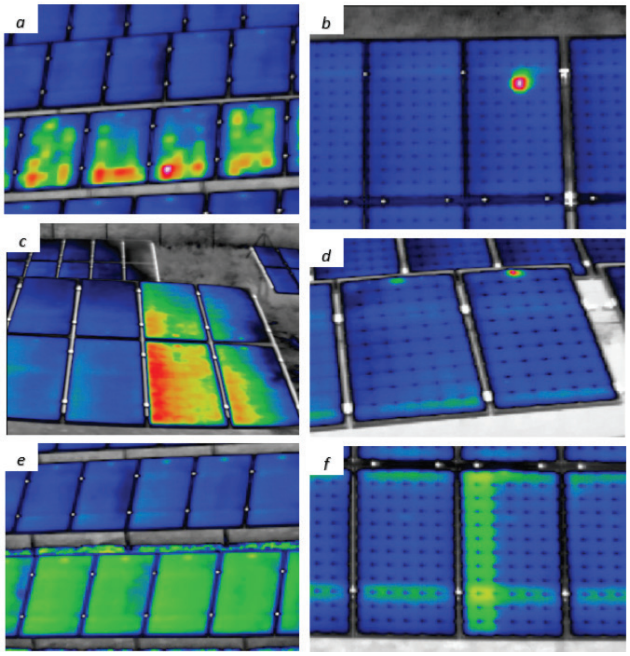

Figure 3: Collage of common solar module faults showing a) short circuited modules, b) an overheated cell, c) reversed polarity connectors, d) an overheated junction box, e) several modules in 'idle mode', and f) a module with a bypassed substring. Adapted from VATh (2016).

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The Journal of Caribbean Environmental Sciences and Renewable Energy
Vol. 2, Issue 1, (2019) doi.org/10.33277/cesare/002.001/02

As seen from Figure 3, the pattern observed from thermographic imaging of faulty modules can be used to determine the nature of the fault. For example, in Figure 3b, the hotspot on the overheating cell is immediately visible. Similarly, in Figure 3d, a hotspot can be seen at the top middle of the module (typically where the junction box is), thus a possible inference is that the junction box is overheating. In Figure 3e, an entire string of modules is idle. Idle meaning the modules are open circuited, i.e. they are not connected to a load. This indicates a connection issue and means the string of modules is not producing any usable energy. This kind of fault would be very serious for any solar array, because of the significant power loss, and is undetectable by regular imaging.

2.3 Fault Detection using Aerial Thermography

An aerial view of a PV array allows the viewer to see many modules simultaneously, much more compared to a ground view. Thus, an aerial view is much more advantageous for inspection purposes. Muntwyler et al. (2015) [9] demonstrated how simple it is to attach cameras (thermal and regular for comparison shots) to a drone and fly over an array. This solution is far more convenient than having on-site personnel manually inspect each individual module as the aerial view allows the operator to see many modules at once.

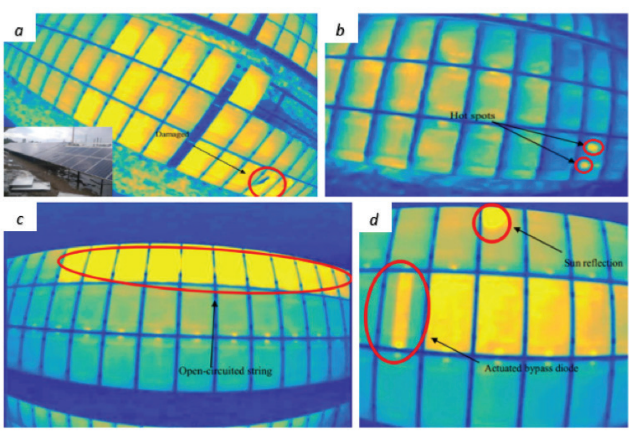

Figure 4: Aerial thermographic images of: a) highlighted damaged module. b) identified module hot spots. c) open circuited string. d) actuated bypass diode and sun reflection. Adapted from Aghaei et al. (2018)[10].

Aghaei et al. (2018) [10], demonstrated the effectiveness of a remote-controlled PV monitoring drone after severe weather conditions, specifically a meteorological tsunami. The thermal images captured by the thermal camera mounted to the drone, were taken in grayscale, and then coloured to aid in the visualization of the faults. The drone operator was able to detect hot spots, defective bypass diodes, and shorted and open circuit strings. These faults, gone undetected, greatly reduce the power output of the plant, hence being able to spot them is a great advantage.

There are other methods of aerial PV inspection as well. PV maintenance companies like Heliolytics, have developed an aircraft mounted sensor package that can be used to get very high-quality, large scale, thermographic images of PV arrays. They also use their own analysis algorithms to detect and diagnose faults in the array.

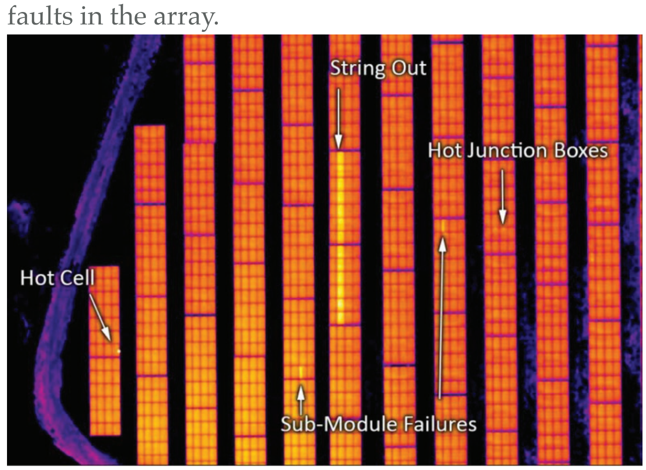

Figure 5: High-resolution infrared aerial imaging of failed strings, modules, and cells

Similar to the smaller scale images in Figure 3, the general thermographic pattern of the faults in Figure 4 allows the operator to diagnose the problems with the modules [3]. The Heliolytics system has the clear advantage of being able to see extremely large sections of the array at once. In Figure 3, the UAS based system could see 30+ modules at a time, whereas the Heliolytics can see upwards of 1,000 modules in a single image.

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The Journal of Caribbean Environmental Sciences and Renewable Energy
Vol. 2, Issue 1, (2019) doi.org/10.33277/cesare/002.001/02

Conclusion

Currently, in the Caribbean, these aerial thermography methods have not been fully implemented. At Content Solar (Clarendon, Jamaica), for example, they use thermography to detect faults. However, the thermographic inspection is done manually by service engineers, on foot. Thus, the inspection process is man-hour intensive (as they have close to 100,000 modules), and as such is not performed as frequently as it should be. Content Solar, and indeed many other solar plants in Jamaica and the wider Caribbean could greatly benefit from aerial thermography. Especially an automated version of such a system. However, there are a variety of factors that may be influencing the lack of use of aerial thermography. These factors could include:

Availability of the technology: While such systems are being used in developed nations, the Caribbean, has limited access to the skills and materials necessary for this technology.

Cost: A lot of the technology used in thermography is proprietary, therefore there is a significant barrier to entry in developing and using these technologies.

Lack of knowledge: Solar operators could be unaware of the technologies used in thermography/aerial fault detection.

It is difficult to determine which of these factors most inhibits the use of aerial thermography, as it is entirely dependent on the specifics of each array and their operators. Therefore, further research could be done into why these systems are not in use in the Caribbean. Nevertheless, as the number utility-scale PV arrays in the Caribbean increases, so does the need for proper maintenance on these systems.

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Climate Change, Environment and Development: The Situation of Persons with Disabilities in the Anglophone Caribbean

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ABSTRACT

The world has been experiencing significant development and as it develops, there are concerns as it relates to the impact on the environment. Research studies have shown major changes in climates around the world and they have major implications for vulnerable groups. One such vulnerable group is that of persons with disabilities (PWDs). Their vulnerability makes them susceptible to varied environmental hazards. However, these individuals are resilient by nature and are able to overcome challenges but non-disabled persons continue to place obstacles in their pathways, thus impacting on their resilience. It is within this context that a study on the situation in the Caribbean as it relates to PWDs and climate change was conducted. Issues of legislation, education, access to information and information communication technologies for PWDs were examined to bolster their resilience to withstand the vagaries of climate change. Two Caribbean countries, Jamaica and Guyana were selected for this analysis. Even though some progress has been made to provide services for PWDs in the region, significant work needs to be done to bolster the resilience of these individuals and bring the Caribbean to adequate preparation for PWDs to withstand the challenges of climate change.

Keywords: *Climate change, development, resilience, persons with disabilities, Jamaica and Guyana.*

INTRODUCTION

Since the new millennium, there has been a growing interest in issues relating to the environment. This burgeoning situation has emerged because of scientific evidence which points to global climate change and the possible implications it has for the survival of mankind. Evidence is showing more expansive natural disasters such as hurricanes, floods, earthquakes, volcanic eruption and other such natural and anthropogenic disasters that constitute an existential threat to countries and their citizens **[1]**. One group that is susceptible and vulnerable to these natural and manmade disasters is persons with disabilities (PWDs). Their susceptibility and vulnerability have come about due to the social, environmental and economic factors that confront them on a daily basis **[2]**.

The problem is further exacerbated because PWDs are among the poorest in societies. Data from the World Health Organisation and World Bank 2011 report on PWDs has shown 85% of this population who are residing in developing countries, being poor **[3]**.

This review article is an analysis of PWDs residing in two Caribbean countries, Jamaica and Guyana and their capacity to withstand the shocks of climate change. In conducting this analysis, various secondary sources were assessed, specifically the situation of legislation, education, access to information and information communication technologies. These are all

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Vol. 2, Issue 1, (2019) doi.org/10.33277/cesare/002.001/03

important issues that assist in building the resilience of PWDs and have been cited in the United Nation's Convention on the Rights of Persons with Disabilities and Optional Protocol (CRPD) as unassailable rights for this vulnerable community [4]. The article is concluded with some recommendations for action to build resilience and hence capacity to respond to climate change.

Theoretical Framework

In conducting this analysis, the interrogation was anchored with the Theory of Resilience. The term resilience refers to an innate quality of hardiness, including the capacity to recover from difficulties over time. In the natural sciences, it is the ability of a substance or object to spring back into shape [5]. According to Unger (2008), resilience is a theory that can inform action [6]. It is a concept that changes our focus from the breakdown and disorder attributed to exposure to stressful environments, to the individual characteristics and social processes associated with either normal, or unexpectedly positive psycho-social development. Climate change threatens the existence of mankind since we are heavily dependent on the natural environment for survival. However, humans have the capacity to recover and overcome these problems caused by climate change over time. What is required are responses to mitigate these situations and include actions such as legislation, education, access to information and information communication technologies (ICTs) that are unassailable in a modern era to build resilience. In order to bolster their resilience among PWDs, greater efforts must be made to protect this vulnerable group through legislation, education, access to information and ICT.

Caribbean societies by their construct and socialisation are very unfriendly to PWDs. Educational facilities, public infrastructure, access to information and access to employment are very limited to these individuals [7]. It is therefore imperative for us to assess the situation of PWDs in the two countries being used as the points of departure to determine their resilience and capacity to respond to climate change.

Guyana

Guyana is the largest country in the Anglophone Caribbean and CARICOM. It is a country that possesses vast forest terrain, mountains and rivers. Their rivers particularly pose problems for citizens residing in the densely populated coastal areas because that section of the country tends to be below sea level [8]. From time to time, the country experiences significant flooding that impact negatively on its development. It has a population of approximately 780,000, and it is estimated that the population of PWDs living in Guyana is approximately 50,000 [9].

Legislation

Guyana signed the United Nations CRPD in 2008 and ratified in September 2014 [10]. During the period of signing and ratifying the CRPD, the Government of Guyana drafted and enacted the "Guyana Persons with Disabilities Act 2010". This piece of legislation was passed unanimously in the National Assembly in December of 2009 and was subsequently assented on November 2nd, 2010 [11].

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Although Guyana has a legal framework to promote and protect the rights of PWDs, limited progress has been made in improving the circumstances of PWDs. Lack of access to information; public buildings; opportunities for meaningful employment and education and access to proper health care, are just a few examples of the discrimination PWDs have to deal with on a regular basis in Guyana. There are no relevant policies guided by the contents of the Guyana PWD Act 2010 in any of the government ministries or agencies to facilitate the delivery of meaningful basic services to PWDs **[12]**.

Education

Sub-parts to articles 14 to 19 of the Guyana PWD Act 2010 provide a detailed framework for the delivery of a meaningful education to children with disabilities by the Ministry of Education **[11]**. Unfortunately children with disabilities are still encountering challenges in acquiring a meaningful education. Presently there is no Special Education Needs (SEN) policy to guide the ministry's work in this area. Most of the work that is done in SEN is done at the central government level and not at the local government level, where the most impact will be felt. It is estimated that approximately six hundred (600) children with disabilities are registered to attend the few SEN schools and mainstream resource units in the public education system. This figure only represents children with disabilities in the political constituencies of Regions 4, 6 and 10. Children with disabilities in Regions 1, 2, 3, 5, 7, 8 and 9 do not benefit from any SEN schools or resource units **[12]**. For PWDs in Guyana to become truly resilient and their capacity to respond to climate change be enhanced, education must be significantly improved for them. It is an unequivocal means of empowering any marginalised group, thus capacitating them to deal with challenges such as climate change.

Access to Information and Information Communications Technology

Access to information and ICTs is another action that is crucial to the building of resilience of PWDs. They must be given the opportunity to access information in user-friendly formats and also, they must be exposed to the Internet that is the major global hub for transmitting information. Those citizens who have access to information and ICTs are best able to respond to climate change as they will be able to put in place preventative measures to protect them against natural and anthropogenic disasters **[1]**. In Guyana, various initiatives have been put in place to provide PWDs with access to information and ICT. In the recently announced budget for 2019-2020 for example, the Government made allocations to digitize all public documents and these will be made accessible to PWDs. Furthermore, funds were allocated for the ICT for Persons Living with Disabilities Project **[13]**. A 2018 ranking of Guyana on the Digital Accessibility Rights Evaluation (DARE) Index has given low ratings for Guyana in terms of ICT accessibility for PWDs. The DARE Index Score is 21/100 **[14]**. The DARE index was established by the Global Initiative for the Inclusion of ICTs for PWDs (G3ICT) and seeks to assess and rank initiatives to include PWDs in the use of ICTs.

Jamaica

Jamaica is one of the most populated countries in the Anglophone Caribbean. It has a population of approximately 2.7 million individuals on the island **[15]**. Data from STATIN identified just over 560,000 PWDs in the 2011 Census. In order to strengthen the resilience of PWDs in Jamaica so that they can withstand challenges emanating from issues such as climate change, various actions, though limited, have been put in place by previous governments. These range from legislation to public education on this vulnerable population.

Legislation

In 2014, the Government of Jamaica passed the Disabilities Act in the Parliament of Jamaica [16]. The legislation came within the context of the inability of the National Policy for Persons with Disabilities [17] to give the necessary support and protection for the members of this vulnerable group. The Disability Act 2014, among other things, seeks to protect persons with disabilities in Jamaica against all forms of discrimination and to allow for them to be included and participate in society on an equal basis with others. Such a legislation is paramount in strengthening the capacity of these vulnerable individuals to withstand some of the challenges associated with climate change. Issues such as access to public facilities, housing, public transportation, employment.

Education

Previous papers have cited the indispensability of education to the empowerment and transformation of PWDs [18], [19]. Without education, PWDs will be unable to grasp the opportunities that are available in a society. Neither will they be able to effectively compete on an equal basis with others. The Disabilities Act has recognised this fact and made provisions for educational services to be provided for members of this vulnerable community at every level. Conspicuously, the Jamaican Education System has been making some efforts to include PWDs. PWDs can be found at every level of the education system. However, it is not extensive and consistent throughout to create the transformative and empowering effect on members of this vulnerable community. Measures are being implemented towards the creation of an inclusive education where PWDs are educated within the same educational institution as the non-disabled. In May 2018 for example, the GOJ commenced an initiative that was spearheaded by this author in the Senate of Jamaica to make one primary and one high school in each constituency across the island, to be accessible to wheel-chair users [20].

Data from a 2015 socio-economic study of 1,014 persons with disabilities revealed that approximately 76% of the respondents did not have any academic certification. Less than 1% of the respondents indicated that they had a degree [16]. If the resilience of PWDs is to be strengthened, radical adjustments will have to be made to these disturbing situations. For vulnerable individuals like PWDs, education is a necessary tool to deal with the daily challenges of a society. Poor or lack of this vital ingredient can only weaken their capacity to respond to various environmental challenges such as earthquakes, floods, hurricanes and anthropogenic catastrophes [21].

Access to Information and Information Communication Technologies

Evidently, we are living in a digital and an information age. It is those citizens who have easy access to information who will be best able to respond to the daily challenges of life. Data from the 2015 socio-economic study shows only a meagre 10% of respondents are using a computer on a consistent basis [16]. Notwithstanding this level of access among PWDs to ICTs, Jamaica is highly ranked among countries in the world in the context of access to ICT for PWDs. Data from the G3ICTs make interesting reading. On the G3ICTs DARE Index, Jamaica has received a score of 61/100 [14]. Access to information is one of the indispensable needs of persons with disabilities [4]. However, this need is being stymied by the high cost of modern technologies to the members of this vulnerable

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The Journal of Caribbean Environmental Sciences and Renewable Energy
Vol. 2, Issue 1, (2019) doi.org/10.33277/cesare/002.001/03

community (Morris & Henderson, 2015). In addition to the hardware, they have to purchase assistive software to make the equipment accessible. Most persons with disabilities in Jamaica are unemployed with data showing over 91% in this category **[16]**. It is imperative therefore, that measures be put in place to assist these individuals in securing the requisite technology that would allow them to access greater levels of information which for example, will allow greater responses to challenges relating to climate change.

Thankfully, through the Universal Service Fund (USF), resources have been allocated to fund initiatives that would allow PWDs in Jamaica to secure their own computer and software. One such initiative is to be found at the UWI Centre for Disability Studies where laptops and software are being provided to PWDs who are studying at the tertiary level. The initiative is also available to PWDs who are employed.

Recommendations

PWDs in Guyana and Jamaica have demonstrated natural traits of resilience. However, for this resilience to be strengthened, certain things must be done to ensure their participation, inclusion and access to services and facilities within the Anglophone Caribbean if they are to withstand the vagaries of climate change **[1]**. Within this context, the following are some recommendations for action.

1. Governments must move to ensure that education systems are more accessible and inclusive of PWDs and consequently, facilities such as ramps, accessible bathrooms, modern technologies and specially trained teachers are in place to cater to the needs of these vulnerable individuals.

2. Governments must move to implement the provisions of the CRPD and the different legislations that have been approved by their parliaments to protect the rights and dignity of PWDs.

3 .PWDs must be placed on Disaster Risk Management (DRM) Committees at the national, regional and local levels.

4. Governments must establish legislation with the appropriate regulations, to make it mandatory for information to be made accessible and in the appropriate format for PWDs within the region.

5. Consistent and sustained public education must be implemented to eradicate the negative attitudes and stigma relating to PWDs in the communities.

Conclusion

There is burgeoning evidence to demonstrate that the world is experiencing climate change. The changes being experienced are manifested in global warming that is contributing to various natural disasters and anthropogenic factors have also been contributing to climate change **[1]**. Whilst the world is experiencing these changes, it poses existential risk to economies, properties and populace. Countries therefore have to concentrate on building or strengthening their capacity to withstand these shocks attributed to climate change. One group that is at serious risk from climate change is PWDs **[2]**, but human beings however; have put in place impediments that have served to stymie the capacity of these vulnerable individuals both indirectly and directly. Efforts must therefore be made to capacitate these individuals because the current situation as seen in these jurisdictions is inadequate to build and strengthen the capacity of PWDs and to enable them to deal with the vagaries of climate change.

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The Journal of Caribbean Environmental Sciences and Renewable Energy
Vol. 2, Issue 1, (2019) doi.org/10.33277/cesare/002.001/03

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