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A Study of Water Consumption in Two Malaysian Resorts

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***Abstract*—**In the effort to reduce water consumption for resorts, more water conservation practices need to be implemented. Hence water audits need to be performed to obtain a baseline of water consumption, before planning water conservation practices. In this study, a water audit framework specifically for resorts was created, and the audit was performed on two resorts: Resort A in Langkawi, Malaysia; and Resort B in Miri, Malaysia. From the audit, the total daily water consumption for Resorts A and B were estimated to be 180m^3 and 330 m^3 respectively, while the actual water consumption (based on water meter readings) were 175 m^3 and 325 m^3. This suggests that the audit framework is reasonably accurate and may be used to account for most of the water consumption sources in a resort. The daily water consumption per guest is about 500 litres. The water consumption of both resorts is poorly rated compared with established benchmarks. Water conservation measures were suggested for both resorts.

***Keywords*—**water consumption patterns, water conservation practices, water audit, water audit framework.

I. Introduction

TOURISM is a very important component in the economy of many countries. The World Tourism Organization estimates that there are more than 633 million international travelers in 1999 and is poised to grow at a rate of 4.1% a year through the first two decades of the new millenium [1]. The hospitality sector is also one of the largest employers. According to the 2007 survey conducted by the National Restaurant Association there are over 12.8 million people employed in over 935 000 locations in the United States [2]. In particular, the highest growth rates in tourism are attributed to the Asian tourism industry in general. This rapid growth in tourism will have a significant detrimental impact on the environment, as more and more hotels will need to be built to cater for the increased tourist arrivals.

Hotels and resorts are also large users of water. Therefore, through water conservation, hoteliers can save money and help towards protecting the environment. Water conservation also provides other benefits, such as reduced infrastructure costs to store water, pumps, and reduced volumes of wastewater that need to be treated and discharged to the sewer or to the environment. Organizations such as the Green Hotels Association, the Coalition for Environmentally Responsible Economies (CERES) and the Green Hotels Initiative are spreading the benefits of green hotels. Hotel certification programs such as Green Globe 21 provide hoteliers with marketable certifications. However, water consumption per room still remains high in many hotels [3].

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Global fresh water consumption has risen faster than it is replenished. Between 1990 and 1995, fresh water consumption increased more than twice the rate of population growth. According to a report released by the International Water Management Institute (IWMI), a third of the world's population (roughly 2 billion people) is facing water scarcity currently [4]. Protecting water resources has become a responsibility for all. In particular, green initiatives can also be implemented for the tourism and hotel industry.

To assess the possibility of implementing green initiatives for hotels and resorts such as reduction in consumption of water and energy, it is important to collect data on the water consumption patterns of a resort. Methods to assess water consumption are similar to residential and non- residential buildings as resorts usually consist of both residential and non-residential components [5]. However, other factors such as number of rooms, hotel activities and occupancy rates also affect the water consumption of a hotel.

In a study of resorts and hotels in Barbados, five hotels (two small, two medium, one large) and seven in St. Lucia (two small, two medium, three large) were surveyed over a three-week period [6]. The data collected included water consumption records (meter readings), bed nights or room nights sold monthly, average length of guests' stays, and average number of guests per room.

This information, coupled with the background information, was analyzed to produce the daily water consumption in the resorts. For the data surveyed included the number of guests, number of rooms, occupancy rates, number of pools, number of kitchens, laundry services, landscaping, and the adoption and implementation of environmental programs. From the study, the daily water consumption per capita for the hotels in Barbados ranged from 300 to 1500 litres for Barbados, and 500 to 2500 litres for St. Lucia, depending on the size of the hotel [6]. The adoption of environmental management programs played a role in affecting the daily water consumption per capita, as the hotels that implemented environmental management programs recorded lower water consumption, even for hotels of the same number of rooms and guests. The study indicated that an effective water management program can significantly reduce the water consumption for hotels. From the above study, a framework for the water audit was created. A more detailed framework which included other water usages such as irrigation, air-conditioning and restaurants would be beneficial, as would a framework that would allow for different water consumption sources or configurations for different hotels. A water audit framework presented by Holmes has been designed to be performed on any type of buildings [7].

This audit framework categorizes and quantifies all water uses. All water use is presented as a balance and accounted for in the audit, eliminating the need for unaccounted-for-water [7]. All uses of water in the system equal the amount of water input by the sources. However, for this study, this audit framework is not entirely appropriate as some of the categories in the framework (for example unauthorized water) are not applicable for hotels. Therefore, for this study, a more specific water audit framework, with flexibility in recording different water consumption sources, will be developed.

This paper presents a study of the water consumption patterns of two resorts, namely Resort A (located in Langkawi, Malaysia) and Resort B (located in Miri, Malaysia) as case studies. Resort A is located at Langkawi's beachfront, along the beach of Pantai Tengah with many other resorts. In 2006, a substantial capital was invested to transform Resort A into a deluxe resort. Resort A has a total of 117 rooms, and is the first resort in Langkawi to implement green practices to preserve the environment. Therefore, there are several environmentally beneficial initiatives being implemented in the resort such as rainwater harvesting, waste recycling and others. Resort B is located in the Brighton Beach area of Miri, and is a well known deluxe hotel with many facilities including swimming pools, gyms, restaurants and others. This resort has a total of 220 rooms. Water audits will be performed in these resorts to determine the water consumption patterns, based on a specially designed water audit framework. Water conservation practices are then suggested for the resorts.

II. Methodology

A. Water Audit Framework

An organized and user-friendly water audit framework for water audits carried out at hotels and resorts was developed to assess water consumption for this study. The framework was created with Microsoft Excel, as spreadsheets are easily manipulated, analysed, and presented. The water audit framework was used to investigate the daily water consumption of all the activities in the hotels and resort being studied, classifying the activities into internal and external uses. Due to space constraints, the water audit framework is not shown here. A summary of its components are as shown in Table I.

TABLE I
Components of the Water Audit Framework

Components	Areas	Items/usage	Example measurements
Water closets	Lobby, offices, bars, restaurants, gyms and others	Faucets, toilets, urinals, sprayers, showers and others	Average flow rate, estimated duration of usage, number of users (peak and offpeak), estimated water volume per usage, estimated water volume per cleaning session, number of cleaning sessions per day, and others
Guest rooms	Toilet, kitchen, others	Faucets, toilets, bathtubs, showers, Jacuzzi, water dispensers, washing machines, private pools	Average flow rate, estimated duration of usage, water volume per usage, occupancy rate, average number of occupants per day, estimated number of usages per day, water volume per cleaning session, number of cleaning sessions per day, and others
Other internal uses	Bars, restaurants, poolside bars, salon, spa, laundry service, baby sitting, indoor pool,	Food and drink preparation, dish cleaning, showers, baths, and others	Estimated amount of food and drinks prepared per day, estimated number of customers, water volume per usage, type and capacity of washing machines, frequency of usage of washing machines, and others
External uses	Pools, fountains, cooling towers for air conditioning, cleaning, landscaping,	Showers, pool maintenance, volume of water replaced, irrigation, cleaning	Water volume per usage, type of irrigation, estimated duration of irrigation and others
Water reuse		Rainwater capture	Number of tanks, tank capacities, and others
Water meter readings			Daily or monthly water meter readings within the study period

To ensure a more accurate audit, variations in the water consumption sources and configurations (for example, number of toilets in the water closet, etc. which depends on the individual resort) were incorporated into the framework. Water consumption for all the activities of a resort is obtained by two methods: Most of the water consumption in the water-consuming features of a resort is evaluated by the product of average flow rate and average duration of usage of the water features, and the product of both of these parameters yields the average water consumption.

Another method to evaluate the water consumption is by taking the product of water volume consumed each time the activity is performed and the number of times the activity is performed each day. Either way is used to determine the water consumption, depending on the activity of the resort. However, the evaluations will be summarized into two equations shown below

$$\textit{Total Water Consumption per Day} = \textit{Average Flow Rate} \times \textit{Average Duration of Usage} \times \textit{Number of Times Item Used per Day} \quad (1)$$

$$\textit{Total Water Consumption per Day} = \textit{Water Consumed per time} \times \textit{Number of Times Item Used per Day} \quad (2)$$

After planning of the water audit framework, site visits were carried out over a period of two weeks each, at both resorts.

The water audit was carried out through daily or weekly walkthroughs, depending on the item being monitored. Estimates of water volume or flowrates were mostly performed in-situ, by measuring the water volume or flowrate with containers. Frequency of usages was obtained by observation (eg. Counting the frequency of usage of the water closet). Other information was obtained through speaking with relevant hotel personnel including staffs from Human Resources department, the Head of the Environmental Department, the Head of the Sustainable Department, the Head of the Engineering Department, and others.

III. Water Consumption for Resort A, Langkawi

A. Water Consumption breakdown in Resort A

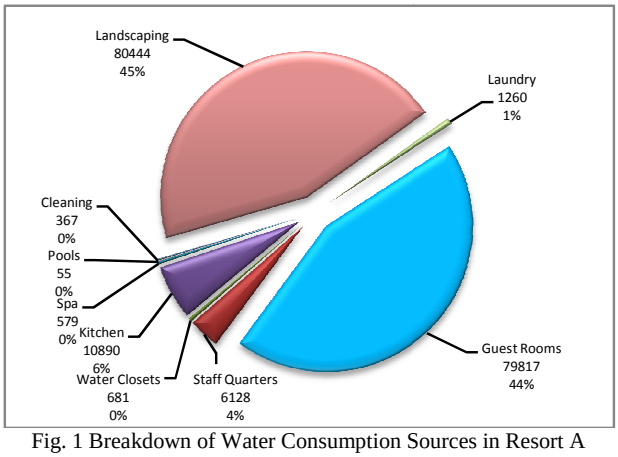

Fig. 1 Breakdown of Water Consumption Sources in Resort A

Fig. 1 shows the water consumption breakdown at resort A. Both landscaping and guest rooms consume the most water for the resort, with proportions of 44% and 45% respectively, adding up to a percentage of 89%. Consumption at the kitchen, staff quarters and laundry are 6%, 4% and 1% respectively. Minor water consumption is observed for water closets, spa, cleaning and pool. The largest amount of water is consumed for landscaping purposes because the resort has a broad area of greenery (14181m^2) which need to be maintained and irrigated every day. As for guest rooms, water consumption is high as it is a major component of the resort. During their stay, guests also consume water for all purposes freely. For resort A, there are 117 guest rooms.

Summing all the water volume yields the daily water consumption of the resort, which is 180m^3. This volume is very near to the actual water consumption obtained from the water meter, which is 175m^3.

B. Water consumption breakdown in guest rooms, water closets, other locations, and for cleaning at resort A

For the resort's guest rooms, both showers and bathtubs consume the most water for the resort, with proportions of 50% and 42% (see Table II). Minor water consumption is observed for toilets, faucets, and bidets in the guest rooms. This suggests that bathing consumes the most water out of guest rooms.

As for water consumption in all the water closets of the resort (see Table II), guest rooms consume the most water for the resort, with a proportion of 92%. There also staff quarters (includes senior and junior quarters) located at the hotel grounds. These quarters and the public consume about 8% in total. A small proportion is observed for water consumption by the public (1%), probably due to only two public water closets being available in the resort grounds. A considerable amount of water consumption is noted for junior quarters, despite its low number of occupants (9 occupants, compared to 23 occupants in the senior quarters).

For water consumption in other facilities of the resort (Table II), the restaurant consumes the most water for the resort (64%), followed by the canteen, spa, bar and pools (26%, 5%, 4% and 1% respectively). A high consumption is seen at the restaurant and bar due to the daily preparation of food and drinks for the guests. For the pool, only a small amount of water is consumed for pool showers. No other pool recharge/cleaning is needed because of the advanced pumping device used at Resort A.

For cleaning activities in the resort, laundry consumes the most water for the resort (77%), followed by housekeeping and other general cleaning (a total of 23%). The consumption for general cleaning and housekeeping is kept low due to simple cleaning with only a mop and bucket of water.

TABLE II
Water Consumption at Resort A's guest rooms, water closets, other locations and for cleaning

Guest rooms	Water closets	Other locations	Cleaning purposes
Showers (50%)	Guest rooms (92%)	Restaurant (64%)	Laundry (77%)
Bathtub (42%)	Senior quarters (4%)	Canteen (26%)	Housekeeping (13%)
Toilet (5%)	Junior quarters (3%)	Spa (5%)	General cleaning (10%)
Faucets (2%)	Public (1%)	Bar (4%)	
Bidet (1%)		Pools (1%)	

The water consumption per guest/staff per day can be determined and are are presented in Table III as shown below.

From the table, it can be deduced that the water consumption per guest for resort A is 500 litres per day. This concurs with a previous study [8]. where it is estimated that a tourist in a resort consumes an average of 300 litres to 850 litres per day. Water consumption in the staff quarters is rather low (153 litres per staff per day for Senior Quarters and 292 litres per staff per day for Junior Quarters).

TABLE III
Daily Water Consumption per Capita at Resort A

Water closet locations	Water consumption (L)	Average number of persons	Water consumption per occupant
Guest rooms	79817	167	478
Senior quarters	3509	23	153
Junior quarters	2620	9	292
Public	681	70	10

The water consumption patterns for Resort A were investigated by recording the main water meter readings daily, with time intervals of 2 hours, from 7am until 11pm everyday, for a week. Fig. 2 shows the daily water consumption patterns in the resort, which is different from established water consumption patterns for residential and institutional sources (Wee, Tan, Hii)

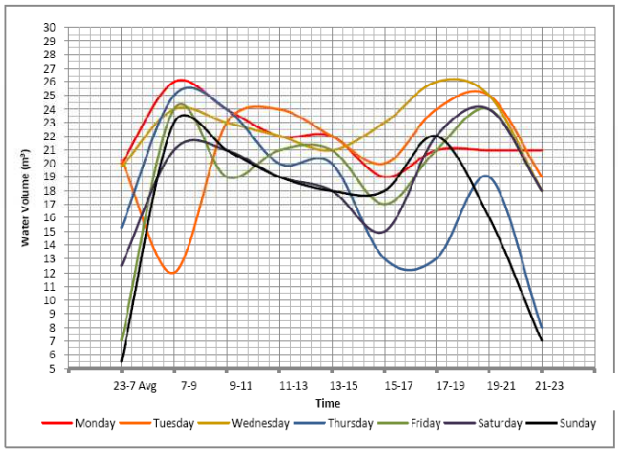

Fig. 2 Diurnal Water Consumption Patterns at Resort A

IV. Water Consumption For Resort B, MIRI

A. Water Consumption breakdown in resort B

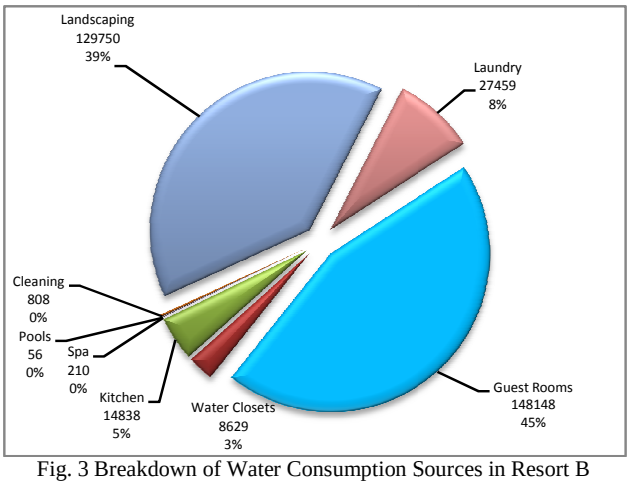

Fig. 3 Breakdown of Water Consumption Sources in Resort B

Fig. 3 shows the water consumption breakdown of resort B. Both landscaping and guest rooms consume the most water for the resort (45% and 39% respectively). Other consumers such as laundry and kitchen add up to a percentage of 13%. Minor water consumption is observed for the water closets, spa, cleaning purposes and pool. As observed in resort A, guest rooms are high water consumers. There are 220 guest rooms in resort B. Landscaping consumes much water because the resort has a huge area of greeneries (48600m^2) which need to be irrigated almost every day. The total daily water consumption for the resort is 330m^3.

This is very close to the actual water consumption obtained from the water meter readings, which is 325m^3.

B. Water consumption breakdown in guest rooms, water closets, other locations, and for cleaning at resort B

In the guest rooms at resort B, as with resort A, the shower and bathtub consumes the most water (50% and 41% respectively, as shown in Table IV). Water consumption for the toilet, faucet and bidet consume significantly less water (9%). This corresponds with the results for resort A. It is also possible that guests of both resorts could take advantage of the facilities during their stay, taking more frequent or longer showers or baths.

As for all of the water closets of the resort, the water closets in the guest rooms consume the most water for the resort (95%, Table IV). Other consumption comes from the gymnasium, staff lockers and public (a total of 5%). As before, guest rooms form the major component of the hotel, and there are 220 guest rooms in resort B. Comparatively, the water consumption for the gymnasium is higher than the staff lockers. A total of 100 entries were recorded for the staff lockers during the water audit, compared to 20 entries for the staff lockers.

For other facilities in resort B, the restaurant consumes the most water for the resort (a total of 93%), followed by the coffee corner, poolside bar, spa, and pools (3%, 3%, 1% and 0.01% respectively, shown in Table IV). Similar to resort A, food preparation is a major task in the hotel's daily routine, thus water consumption is significant. As for the pool, consumption is negligible, as only pool showers are considered in the study. No significant water consumption is recorded for other activities such as maintenance for the pool.
For cleaning activities in the resort, laundry consumes the most water for the resort, with a proportion of 97%. Minor water consumption is incurred for housekeeping and general cleaning purposes (2% and 1% respectively). These cleaning activities are simple and do not involve heavy water usage. However, a significant amount of bed linen, towels, staff uniforms and guest laundry is laundered every day, resulting in significant water consumption.

TABLE IV
Water Consumption at Resort B's Guest Rooms, Water Closets, Other Locations and for Cleaning

Guest rooms	Water closets	Other locations	Cleaning purposes
Showers (50%)	Guest rooms (92%)	Restaurant (93%)	Laundry (97%)
Bathtub (41%)	Gymnasium (2%)	Coffee corner (3%)	Housekeeping (2%)
Toilet (6%)	Staff lockers (2%)	Poolside bar (3%)	General cleaning (1%)
Faucets (2%)	Public (1%)	Spa (1%)	
Bidet (1%)		Pool (0%)	

From Table V, the water consumption per person for resort B is 500 litres per day, in agreement with [8]. Water consumption in the staff lockers and the gymnasium is rather low(51 litres per staff per day for staff lockers and 139 litres per guest per day for gymnasium).

TABLE V
DAILY WATER CONSUMPTION PER CAPITA AT RESORT B

Water closet locations	Water consumption (L)	Average number of persons	Water consumption per occupant
Guest rooms	148148	308	481
Staff lockers	3825	75	51
Gymnasium	2765	20	39
Public	2039	90	23

V. WATER MANAGEMENT PRACTICES FOR RESORTS A AND B

In addition to a water audit, the water management practices, in particular any water conservation practices of both resorts A and B were studied. As stated previously, resort A implements environmentally beneficial initiatives in many of its activities. An environmental department was set up as part of its operational departments, and it studies the environmental impacts of its activities and makes recommendations to minimize environmental impact. The environmental department also monitors its water and energy consumption, keeping records from several years. The water conservation objective of the resort is to reduce dependency on government-supplied treated water. The establishment of the environmental department is a highly commendable initiative in efforts to monitor and minimize consumption of resources and environmental damage.

At resort A, alternative water sources include rainwater, and groundwater. Rainwater harvesting is also carried out at resort A, and a total of 85 water tanks are used for harvesting rain water, comprising of 70 large tanks with a capacity of 3344 litres each and 15 small tanks with a capacity of 2090 litres each, with a total capacity of 264382 litres overall, installed around the resort. Rain water from these tanks is channeled to taps located around the resort area, which are mostly used for landscaping. Due to the high water table at the resort area, groundwater is acquired easily though water wells. There are 3 wells located near the organic farm of the resort. The groundwater is mostly used for landscaping activities.

For the fish ponds throughout the resort, the pond is filled up naturally by rain water runoff. Runoff from the pavement will flow into storage compartment in front of the pond. The storage compartment can store up to 10754 litres of water.

During the study, an additional water source, that is air conditioner water harvesting was surveyed. Based on a duration of 2 weeks, a total of 934 litres of water was harvested [5]. The harvested water may be used for landscaping activities whenever necessary. This may help to conserve some water for the resort for landscaping activities.

For Resort B, no water management monitoring is carried out at the time of writing, nor water conservation measures implemented. However, water meter readings are recorded daily and kept by the engineering department for a duration of three years. Maintenance staffs for the resort check water pipes for leakages weekly. Any leakages identified are recorded and are repaired within the month. In its kitchen, for minor dishwashing tasks, the dishes are cleaned with standing water in the sinks rather than running water. This conserves some water.

For resorts like resort A and B, gaining senior management commitment and support to develop a water conservation policy is a prerequisite to achieving significant water conservation for the resort. For instance, gaining financial support by the senior management is crucial when implementing all the adopted water conservation practices for the resort. Both technical opportunities and behavioral approaches that are designed to improve water conservation practices within the hotel should be given equal consideration [3]. Technical opportunities mostly involve the replacement or modification of current water utilities of the resort, to increase their efficiency in saving water. Behavioral approaches however, involve the staffs and guests awareness programs. The major steps of water conservation are:

1. Developing a water management plan
2. Identifying the best opportunities
3. Staff awareness programs
4. Guest awareness programs

VI. DISCUSSION

A. Water Audit Framework

For Resort A, the daily water consumption of the resort is $180m^3$. This figure is close to the actual water consumption obtained from the onsite water meter, which is $175m^3$. Similarly for Resort B, the daily water consumption of the resort is $330m^3$. The actual water consumption obtained from the water meter is $325m^3$. For both resorts, a slight over-estimation of 5 m^3 was observed. This is mainly due to assumptions or simplifications made during the water audit. This shows that the suggested water audit framework used for the water audits in both resorts is reasonably accurate, and accounts for almost all water consumption in both resorts. The water audit framework includes the flexibility to allow for specific water consumption sources or different configurations of sources such as bathrooms and kitchens. This has helped obtain a more accurate estimate of the water consumption for both resorts.

B. Water consumption for Resorts A and B

The water consumption baseline provided by the International Tourism Partnership (ITP), is shown in Table VI, where the benchmark for water use in guest rooms in litres per guest per night of the resort is presented based on the size of the resort, while Table VII shows the benchmark for water use in guest rooms in litres per guest per night of the resort based on the weather of the location.

TABLE VI
WATER EFFICIENCY BENCHMARK FOR RESORTS BY INTERNATIONAL HOTELS ENVIRONMENTAL INITIATIVE [9]

Property size	Water use rating (Litres/guest.night)			
	Good	Fair	Poor	Very poor
<50	<440	116 – 510	510 – 585	>585
50 – 150	<585	585 – 675	675 – 810	>810
>150	<670	670 - 860	860 – 985	>985

TABLE VII
WATER EFFICIENCY BENCHMARK FOR GUEST ROOMS BY INTERNATIONAL TOURISM PARTNERSHIP [10]

Weather	Water Use Rating (Litres/guest.night)		
	Good	Fair	Poor
Temperate	250	250 - 300	>300
Mediterranean	270	270 - 320	>320
Tropical	300	300 - 350	>350

For Resort A (117 rooms), its total water consumption per day is around 175 m^3, which results in 880 litres per guest per night, based on an average number of occupants (includes guests and staff) of 199. As shown in Tables VI and VII the water consumption pattern is very poor in comparison with the benchmark. For Resort B (220 rooms), the total water consumption per day is 325 m3, resulting in the water consumption of 1055 litres per guest per night (based on an average number of occupants of 308). The water consumption per guest in guest rooms for both resorts is about 500 litres per day. Clearly, both resorts does not meet the requirements set by ITP, as both resorts are categorized in the poor zones of the two tables, even though the resorts have adopted some of the water conservation practices.

C. Water conservation practices

Water audits conducted by Sydney Water show that average water savings of 20% are possible without compromising guest comfort levels [11]. Therefore, it is recommended for both resorts to reduce their water consumption by a quarter (25% of its total daily water consumption); that is, a reduction to 130 m^3 for Resort A, and 240 m^3 for Resort B.

Resort A has made the effort to conserve potable water. The installation of rainwater tanks has helped to reduce consumption of piped water because rain water is used for much of the activities in the resort. Underground water wells are useful if the water table of the location remains high. Although more water conservation practices should be carried out at Resort B, some good practices are evident, such as the weekly check for leakages around the resort.

Suggested water conservation practices for both resorts include:

1. Replace current shower heads with water-efficient shower heads in the resort (in particular for guest rooms).
2. Install aerators for all the faucets in the resort.
3.Replace the classic wok stoves in the kitchens with waterless wok stoves.
4. Further implementations of the staff and guest awareness programs.

VII. CONCLUSION

A water audit framework that is suitable for hotels and resorts was created for this study. The water audit framework includes flexibility to account for individual water consumption sources or configurations. From the water audit carried out with the created water audit framework, for Resort A, an estimated water consumption of 180m^3 per day was obtained. During the same period, the water consumption was 175m^3 per day as recorded from the water meters. For resort B, the estimated water consumption was 330m^3 per day, while the actual water consumption was 325m^3 per day. This suggests that the framework used is reasonably accurate.

The most significant source of water consumption for both resorts is the guest bathroom, as shown in Tables III and IV.

The water consumption per guest for both resorts is about 500 litres per day. A baseline of water consumption for Resorts A and B was obtained, and their daily water consumption is 175 m^3 and 325 m^3 respectively. The water consumption at both resorts rate as “poor” and “very poor” according to the benchmark set by International Tourism Partnership. It is recommended that both resorts adopt water conservation practices suggested in this study to reduce their water consumption.

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