*International Research Journal of Environment Sciences* E-ISSN 2319–1414
Vol. **5(9),** 55-62, September **(2016)** *Int. Res. J. Environment Sci.*

# Seasonal Hydro-Climatic Consequences on Fish Harvests in the Vavuniya Reservoir, Sri Lanka

**A.E.S. Patrick[1*] and S. Kuganathan[2]**
[1]Department of Bio-Science, Faculty of Applied Science, Vavuniya Campus, University of Jaffna, Sri Lanka
[2]Department of Fisheries, Faculty of Science, University of Jaffna, Sri Lanka
patrickvavuniyacampus@gmail.com

**Available online at: www.isca.in, www.isca.me**
Received 3rd July 2016, revised 27th August 2016, accepted 9th September 2016

## Abstract

*Vavuniya reservoir is a tropical lowland shallow irrigation tank located in Vavuniya District, Northern Province, Sri Lanka. As it is situated in the dry zone, experiencing the water scarcity probably due to the climate related changes which in turn affect the seasonal hydro-climatic factors recently. This study focused on the effects of seasonal hydro-climatic factors on fish harvests in this reservoir. The major hydro-climatic factors are monthly total rainfall (RF) and monthly mean water level (WL). RF, WL, catch/harvest and effort data were collected from January 2013 to December 2014. Semester and quarter wise categorization of both years were done based on RF and WL by using moving average techniques. There was no correlation between RF and WL (p= 0. 606 & r = 0.231) due to irrigation. In 2013, the annual fish harvest was 16 130 kg and in 2014 it was 27 005 kg. The WL showed a strong negative correlation and a significant (p=0.037) relationship between most catchability variables compared with RF. Direct and the indirect effect of climate related changes influenced the seasonal pattern of this hydro-climatic factors which in turn affect the fish harvest and fish species survival in this reservoir. Findings of this study reflected the current changes in seasonality and its consequent threats to fisheries. Hence, optimal fish harvests can be achieved via rational understanding of this baseline information in Vavuniya reservoir.*

**Keywords:** Seasonality, Hydro-climatic factors, Fish harvest.

## Introduction

Vavuniya reservoir is a medium perennial reservoir which lies between 8°45'13.75 - 59.23" N latitude and 80°30'7.50 - 53.21" E longitude in Northern Province, Sri Lanka (Figure-1). This reservoir spreads over about 1.328 km$^2$ of surface area. Major water sources of this reservoir are north-east monsoonal rains and inter-monsoonal rains and seasonal spilling from nearby reservoirs. The mean annual rainfall was 1000 – 1500 mm in Vavuniya District[1].

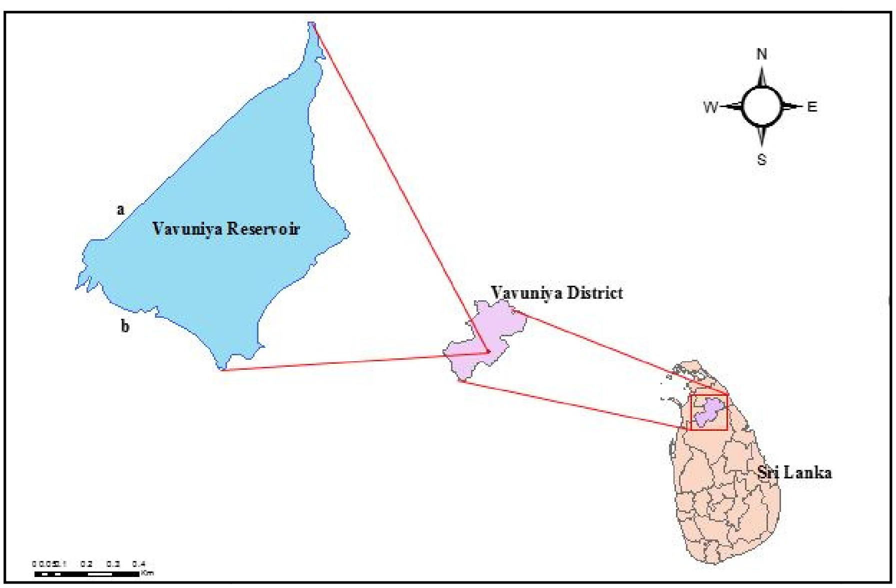


**Figure-1**
**Map showing the study site (Vavuniya reservoir) (a) Poonthottam landing site, (b) Rampaikkulum (Urban drainage inlet)**

Seasonal variations of the rainfall determine by the temporal weather characteristics and the global climate change in the Northern region Sri Lanka[2]. Alterations in the seasonal hydro-climatic factors like rainfall and water level probably due to the climate related changes. Draining water for agriculture even from the dead storage resulted completely dried out from June to September 2012 and dramatic drop in water level occurred during September, 2014 in Vavuniya reservoir. A scientific study on hydro-climatic factors and its influences of fisheries management has never performed for Vavuniya reservoir. Effects of seasonal hydro-climatic factors on fishing practices, management strategies and fish biology remain highly disputed in Vavuniya reservoir.

Inland reservoirs are doted globally and sensor the climate change in number of ways which reveal the information about the effect of climate change via only proper understanding[3,4]. Pronounced effects of global warming are now being observed in many inland lakes and reservoirs, with severe consequences for the ecosystem services they used to provide. This justifies the urgent need to study the present status of the inland fisheries in the Vavuniya reservoir to meet the sustainable and optimum fish harvests.

## Materials and Methods

**Data Collection:** Weekly filed visits were made to landing sites in order to collect, catch, effort and water level data from January, 2013 to Decemper 2014. Daily rainfall data were obtained from the Meteorology Department, Vavuniya and the monthly total rainfall (RF) were calculated. The monthly mean water level (WL) of the Vavuniya reservoir was calculated after getting the weekly data by direct observation. Monthly total catch of the reservoir was estimated by using the daily fish catch data obtained from the logbook of the fishers.

**Catch statistics for hydro-climatic categories:** Determination of these quarters were done by calculating 3 month moving averages of monthly total rainfall patterns in order to obtain heavy, medium, low and very low quarters[5]. Additionally, 6 month moving averages were also calculated to categories high and low RF semester of the annum. Catch statistics were used to calculate fish species wise and total catch with respect to the above categories of the annum. Likewise water level based 4 quarters and 2 semesters were determined with respect to its catch statistics in both years.

**Determination of catch and effort:** Catch assessment surveys were conducted to obtain the necessary information (number of fishers, number of crafts and fishing gear). Fish catch data such as number and types of crafts and gear, commercial fish catches, fishing duration, fishing methods were obtained by using questionnaires and interviewing fishers. Mean Catch per Unit Effort (kg/fisher/day and kg/fishing gear/day) and other catchability variables such as fishing days/fisher/month, total number of boat days/month and total number of gillnet days/month were determined[5].

## Results and Discussion

**Hydro-climatic factors in the Vavuniya reservoir**: Although the rainfall was the major water source (North-East monsoon and 2nd inter-monsoon), dynamics of the water level in Vavuniya reservoir, Sri Lanka depended on irrigation as well. Consequently, the Pearson correlation coefficient between monthly total rainfall and monthly mean water level (Figure-2) was less positive and insignificant ($p= 0.606$ and $r = 0.231$).

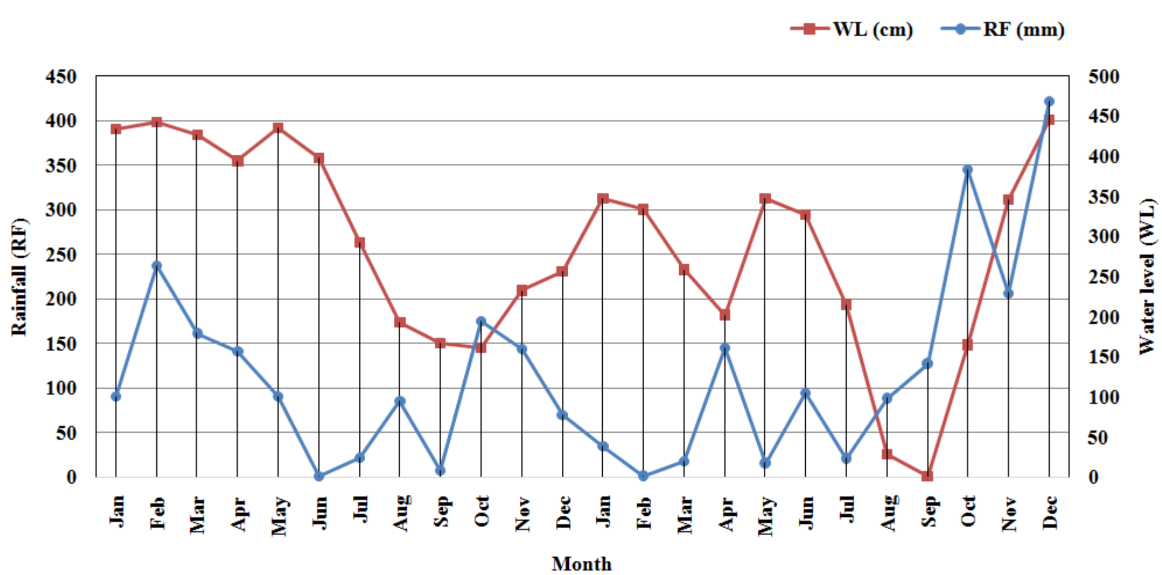


**Figure-2**

**Seasonal fluctuation of hydro-climatic factors (rainfall [RF] and water level [WL] in Vavuniya reservoir) for the period of January, 2013 to December, 2014**

In this reservoir the annual fish harvest in 2013 was very low (16 130 kg) compared to previous years[6]. This was mainly due to the unprecedential drought prevailed from June up to September, 2012 resulted complete eradication of fish, which in turn led to harvesting undersized fish (recently stocked fingerlings and naturally immigrated younger fishes) were the main reasons[7]. Long term water level fluctuation in reservoirs effects the fish population structure and the estimates of fish harvest and management[8-10].

In 2014 the annual total fish harvest was 27 005 kg due to subsequent stocking, natural recruitment and increased efforts. However, dramatic decline in water level happened during July to September, 2014 due to over-extraction for irrigation even from the dead storage of this reservoir (Figure-3).

Almost all the indigenous fish species in the Vavuniya reservoir were vulnerable due to the water scarcity, observed in July 2014 (Figure-4). Therefore, Vavuniya reservoir fish production experiencing vulnerability probably because of climate related changes that affect the seasonality of hydro-climatic factors.

The direct cause may be due to the climate change and its consequent effects on the remarkable changes of rainfall patterns. And the indirect effect was irrational irrigation practices caused sudden drop in the water level. These kind of similar impacts were found in world wide.

Many inland fisheries are threatened by alterations to water regimes. In severe drought, cause vanishing of whole lakes and waterways in Africa[11]. Fluctuations in the hydro-climatic factors influenced the catch (harvest) and effort and biology of fish, resulted the non-uniformity of the catch distribution in Vavuniya reservoir. This non-uniformity of the monthly catch distribution of each species was found to be significant ($p<0.05$) throughout the years 2013 and 2014.

**Catch statistics for rainfall based quarters:** In Vavuniya District during the past couple of decades (1992 - 2012) the heavy rainfall based quarters were found among Sep-Nov, Oct-Dec and Nov- Jan quarters (Table-1).

**Figure-3**
**Over extraction for irrigation leads to Zero WL during Aug – Sep, 2014**

**Figure-4**
**Fish death in Vavuniya reservoir happened during July to August, 2014**

**Table-1**
**Heavy rainfall (RF) based quarter of the past 2 decades in Vavuniya District**

| Year | Three months moving average of RF (mm) | Heavy RF based Quarter |
|---|---|---|
| 1992 | 203.1 | Sep-Oct-Nov |
| 1993 | 389.4 | Oct-Nov-Dec |
| 1994 | 189.0 | Sep-Oct-Nov |
| 1995 | 143.7 | Sep-Oct-Nov |
| 1996 | 220.5 | Oct-Nov-Dec |
| 1997 | 326.4 | Oct-Nov-Dec |
| 1998 | 270.8 | Nov-Dec-Jan |
| 1999 | 255.9 | Oct-Nov-Dec |
| 2000 | 274.3 | Nov-Dec-Jan |
| 2001 | 233.4 | Oct-Nov-Dec |
| 2002 | 231.2 | Oct-Nov-Dec |
| 2003 | 218.5 | Nov-Dec-Jan |
| 2004 | 262.3 | Oct-Nov-Dec |
| 2005 | 214.8 | Oct-Nov-Dec |
| 2006 | 187.9 | Oct-Nov-Dec |
| 2007 | 287.1 | Oct-Nov-Dec |
| 2008 | 234.9 | Oct-Nov-Dec |
| 2009 | 281.5 | Oct-Nov-Dec |
| 2010 | 283.8 | Nov-Dec-Jan |
| 2011 | 315.6 | Nov-Dec-Jan |
| 2012 | 432.8 | Oct-Nov-Dec |
| **2013** | **200.5** | **Feb-Mar-Apr** |
| 2014 | 361.0 | Oct-Nov-Dec |

During heavy rainy season fishers tend to cease fishing and involving in fish (fingerling) stocking as a management strategy. However, there was a shift in heavy rainfall based quarter occurred in 2013 as Feb-Apr, indicating irregular rainfall pattern. Consequently fishers continued fishing throughout the year 2013 without ceasing fishing and stocking in this heavy rainfall period unlike in the past years[7].

This may be due to the consequences of climate related changes on the seasonal rainfall pattern in Vavuniya, Sri Lanka. The remarkable change in rainfall that decreasing trend in number of rainy days and mean annual rainfall in Vavuniya District due to climate change[12].

Among rainfall based quarters, the total harvest increased with decreasing rainfall (heavy rainfall to low rainfall quarters). Total quantity of fish harvested during low rainfall periods was always higher[13]. However, lower RF based quarter (Aug–Oct) received comparatively higher fish harvest than very low RF based quarter (May-Jul) in 2013. This happened due to the higher WL found in the very low RF based quarter compare to the low rainfall based quarter, pinpointing the importance of WL fluctuations.

In 2014 the trend of RF based quarters and its respective harvest was not similar to the year, 2013. The very low (Jan-Mar), low (Jul-Sep) and medium (Apr- Jun) rainfall based quarters indicated an increasing trend in the fish harvest e.g. 7 623 kg, 8 986 kg and 10 396 kg respectively.

However, heavy rainfall based (Oct-Dec) quarter showed zero harvests in 2014, since the water level played a major role than rainfall for the fish harvest in Vavuniya reservoir. In addition in September, 2014 WL was zero while there were a few pockets of water in the reservoir bed. Subsequently, heavy RF occurred from October to December 2014 contributed to the zero harvest due to stopping fish harvest. When reckoning the semester wise categorization, higher harvests (8 614 kg) occurred in lower RF semester (Apr- Sep) and lower harvest (7 516 kg) in higher RF semester (Oct-Mar) in 2013. In 2014 higher harvests (24 949 kg) observed in lower RF semester (Feb- Jul) and lower harvest (2 056 kg) in higher RF semester (Aug- Jan) of the same year (2014) indicating the impact of RF.

**Catch statistics for water level based quarters:** There was a steady increasing pattern in total fish harvests with decreasing WL in 2013. The WL based quarters were categorized as higher (Jan-Mar) = 1 409 kg, medium (Apr-Jun) = 4052 kg, Low (Jul-Sep) = 4561 kg and very low (Oct-Dec) = 6107 kg in 2013. In 2014, WL based quarters were found as very low (Sep-Nov), Low (Jun-Aug), medium (Mar-May) and high (Dec-Feb) and the higher harvests were observed from Mar- May (12 448 kg) and low harvests (3 736 kg) were in Dec- Feb (within the same year). Zero harvests were in Sep-Nov due to zero water level triggered in September as a result of over extraction of water for cultivation (Plate 4.2). Zero catches in some months are very common in several countries especially in East Java zero catches were higher[14]. Reckoning the semester wise categorization, high WL semester (Jan- Jun) and low WL semester (Jul-Dec) were obtained in both years 2013 and 2014. In 2013 high WL semester (Jan- Jun) obtained lower harvests (5 462 kg) and low WL semester (Jul-Dec) got higher harvests (10 668 kg). However, in 2014 high WL semester got higher harvests (18 019 kg) and low WL semester obtained low harvests (8 986 kg) justified by the zero catches.

**Annual seasonal fluctuations of catch and effort:** Hydro-climatic factors (RF and WL) were the independent variables which affected the catch (harvest) and effort (catchability variables) in Vavuniya reservoir. Fishers used gill nets of 3½", 3¾", 4" and 4½" (stretched mesh sizes) as major fishing gear. However, in 2013, since larger fish were not available only 3½" and 3¾" gillnets were used, which resulted in reduction in the annual total harvest than 2014 (Table-2).

From April, 2014 fishers used gill nets of 4", 4½"and 4¾" and increased their effort to harvest higher number of larger fish (Table-2). Fishers could able to forecast declining WL in the latter part of the year 2014 as happened earlier in 2012. Thus, use of appropriate fishing methods and suitable changes in effort according to the seasonal changes in hydro-climatic factors are important for obtaining the optimal harvest particularly in Vavuniya reservoir.

Pearson correlation coefficient (r) between monthly total harvest and WL showed significantly ($p=0.02$) stronger negative correlation when compared with RF in 2013 and 2014 (Table-3). This was due to the significantly high contribution of *Oreochromis sp*. (79-89%) to the monthly total harvest. *Oreochromis sp*. catchability depended mainly on water level rather than rainfall[5].

Increase in WL, significantly ($p<0.05$) reduced the catchability variables (total number of gillnet days/month, total number of boat days/month and number of fishing days/fisher/month) in 2013 and 2014 (Table-3). However, rainfall did not show any significant relationship with these catchability variables. Comparatively, RF occurring very short period and the resulted WL existing lengthen period. Thus, fishing efforts mainly depended on WL and slightly depended on the direct RF in Vavuniya reservoir.

There was a strong negative correlation between monthly average WL and Catch Per Unit Effort (CPUE) in kg/fisher/day. Setting gillnets and fishing in the reduced WL was easy in reservoirs. Due to the possibility of high CPUE, more fishers tend to engage in fishing for long duration during the lower WL periods. Negative relationship between the water level and CPUE in Nigerian reservoirs indicated the difficulty of harvesting fish with expanded volume of water[15].

**Table-2**
**Hydro-climatic factors and respective harvest data**

| Month of year 2013-2014 | Hydro-climatic factors | | Catchability | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | RF (mm) | WL (cm) | Total Harvest (kg) | Harvest Per Unit Effort | | No. of fishing days per Fisher | No. of boat days | | No. of Gillnet days | | Total No. of Gillnet days |
| | | | | kg/ fisher/ day | kg/ gear/ day | | Canoe | ILT | 3 ½” | 3 ¾” | |
| Jan | 100.9 | 390.7 | 479 | 0.63 | 0.11 | 11 | 119 | 25 | 425 | 225 | 650 |
| Feb | 264.4 | 398.1 | 412 | 0.84 | 0.17 | 11 | 125 | 22 | 400 | 225 | 625 |
| Mar | 179.6 | 384.5 | 519 | 1.08 | 0.18 | 11 | 119 | 25 | 450 | 250 | 700 |
| Apr | 157.5 | 354.9 | 707 | 1.62 | 0.26 | 19 | 213 | NIU | 900 | 450 | 1 350 |
| May | 100.8 | 392.3 | 953 | 1.05 | 0.13 | 20 | 225 | NIU | 650 | 1 200 | 1 850 |
| Jun | 1.7 | 358.1 | 2 392 | 2.34 | 0.30 | 23 | 256 | NIU | 700 | 1 450 | 2 150 |
| Jul | 24.5 | 263.5 | 1 331 | 1.70 | 0.12 | 18 | 200 | NIU | 950 | 1 900 | 2 850 |
| Aug | 95.3 | 173.9 | 1 953 | 1.40 | 0.13 | 24 | 261 | NIU | 975 | 1 975 | 2 950 |
| Sep | 8.3 | 150.6 | 1277 | 2.60 | 0. 30 | 20 | 217 | NIU | 675 | 1 375 | 2 050 |
| Oct | 194.9 | 144.9 | 2 373 | 2.20 | 0.20 | 23 | 250 | NIU | 800 | 1 625 | 2 425 |
| Nov | 160.3 | 209.4 | 2 438 | 2.70 | 0.27 | 21 | 231 | NIU | 775 | 1 525 | 2 300 |
| Dec | 78.3 | 231.1 | 1 295 | 2.50 | 0.25 | 23 | 250 | NIU | 850 | 1 700 | 2 550 |
| Jan | 39 | 312.8 | 1 841 | 2.11 | 0.20 | 25 | 225 | NIU | 1550 | 1175 | 2 725 |
| Feb | 2 | 300.5 | 2 075 | 2.50 | 0.25 | 26 | 250 | NIU | 1670 | 1060 | 2 730 |
| Mar | 20 | 232.9 | 4 084 | 3.50 | 0.35 | 27 | 294 | NIU | 1475 | 875 | 2 940 |
| Apr | 162 | 181.9 | 5 212 | 8.92 | 0.90 | 27 | 350 | NIU | 840 | 860 | 2960* |
| May | 18 | 312.8 | 2 853 | 2.51 | 0.25 | 26 | 288 | NIU | 650 | 1100 | 2850* |
| Jun | 105 | 294.7 | 2 146 | 2.70 | 0.27 | 25 | 275 | NIU | 450 | 800 | 2690* |
| Jul | 24 | 193.7 | 6 842 | 8.30 | 0.84 | 27 | 292 | NIU | 550 | 775 | 2875* |

ILT-Inflated lorry tube, a modified fishing method used in newly flooded areas during spilling, (NIU) Not in use and gillnet types categorized according to stretched mesh sizes 3 ½, 3 ¾, 4½ & 4¾ inches (* 4½ & 4¾ inches are used for only 4 months period in 2014).

**Table-3**
**Statistical summary of catchability variables with hydro-climatic factors**

| Catchability variables | Hydro-climatic factors | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Rainfall (RF) | | | | Water level (WL) | | | |
| | p-value | | r-value | | p-value | | r-value | |
| | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 |
| Total harvest | 0.381 | 0.701 | -0.278 | 0.178 | 0.020 | 0.003 | -0.658 | -0.922 |
| CPUE (kg/gear/day) | 0.750 | 0.255 | -0.100 | 0.498 | 0.290 | 0.002 | -0.327 | -0.936 |
| CPUE (kg/fisher/day) | 0.200 | 0.253 | -0.394 | 0.500 | 0.009 | 0.002 | -0.713 | -0.935 |
| No. of fishing days/fisher | 0.150 | 0.849 | -0.430 | 0.089 | 0.010 | 0.017 | -0.670 | -0.842 |
| No. of boat days | 0.159 | 0.480 | -0.430 | 0.323 | 0.020 | 0.038 | -0.637 | -0.782 |
| No. of gillnet days | 0.084 | 0.823 | -0.518 | 0.105 | 0.004 | 0.037 | -0.750 | -0.784 |

## Conclusion

Consequences of climate related changes via hydro-climatic fluctuations on the sustainable fish harvests in the Vavuniya reservoir were clearly visible. Unpredictable changes in the seasonal rainfall pattern which in turn affecting the water level directly and indirectly (irrigation). Fish harvests and fish survival mainly depended on these seasonal hydro-climatic factors. Therefore, rational understanding and more research activities needed locally and as well as regionally regarding inland fisheries with respect to the hydro-climatic changes.

## References


1. Chandrapala L. (1996). Trends and variability of rainfall and temperature in Sri Lanka Reports no. 26. Kinter J.L. and Schneider E.K. Centre for Ocean–Land- Atmosphere Studies, Calverton, Maryland, 90.
2. Piratheeparajah N. (2015). Spatial and Temporal Variations of Rainfall in the Northern Province of Sri Lanka. *Journal of Environment and Earth Science*., 5(15), 179-189.
3. Williamson C.E., Saros J.E., Vincent W.F. and Smol J.P. (2009). Lakes and reservoirs as sentinels, integrators, and regulators of climate change. *Limnology and Oceanography,* 54(6), 2273-2282.
4. Vincent W.F. (2009). Effects of climate change on lakes. G. E. Likens, Encyclopedia of inland waters, Elsevier, 55-60.
5. Dematawewa C.M.B, Wickremasinghe E.S and Edirisinghe U. (2008). Some effects of seasonal hydro-climatic factors on catchability of fish in minor-perennial Sorabora reservoir, Sri Lanka. *Sri Lanka Journal of Animal Production,* 8, 39-52.
6. Statistical Handbook of Vavuniya District (2013). District Planning Secretariat. District Secretariat, Vavuniya, Sri Lanka.
7. Patrick A.E.S., Kuganathan S. and Edirisinghe U. (2015). Effects of hydro-climatic fluctuations on catchability of fish in Vavuniya reservoir, Sri Lanka. *Tropical Agricultural Research*, 26(2), 402-408.
8. Beam J.H. (1983). The effect of annual water level management on population trends of white crappie in Elk City, Reservoir, Kansas. *North American Journal of Fisheries Management*, 3, 34-40.
9. De Silva S.S. (1988). Reservoirs of Sri Lanka and their fisheries. FAO fisheries technical paper No. 298, Rome, 128.
10. Amarasinghe U.S., Nissanka C. and De Silva S.S. (2001). Fluctuations in water-level in shallow, irrigation reservoirs: Implications for fish yield estimates and fisheries management. De Silva, S.S., *Reservoir and Culture-based Fisheries: Biology and Management.* ACIAR Conference 98, *Australian Centre for International Agricultural Research*, Canberra, Australia, 101-110.
11. Coe M.T. and Foley J.A. (2001). Human and natural impacts on the water resources of the Lake Chad basin. *Journal of Geophysical Research – Atmospheres*, 106, 3349-3356.
12. Manawadu L. and Nelun Fernando (2008). Climate Change in Sri Lanka. *Review Journal of the University of Colombo*, 1(2).
13. Hirimuthugoda N., Wickramatilake Y.P.S. and Wijerathna W. (2008). Socio-economic status of fishermen and present

fishing industry in Minneriya reservoir- A case study. *Sri Lanka Journal of Animal Production,* 5, 103-109.

**14.** Pet J.S., Van Desen W.L.T., Machiels M.A.M., Sukkel M., Setyohadi D. and Tumuljadi A. (1997). Catch, effort and sampling strategies in the highly variable sardine fisheries around East Java, Indonesia. *Fisheries Research*, 31(1-2), 121-137.

**15.** Moses B.S., Udoidiong O.M. and Okaon A.O. (2002). A statistical survey of the artisanal fisheries of south-eastern Nigeria and the influence of hydro-climatic factors on catch and resource productivity. *Fisheries Research.*, 57(3), 267-278.