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OPERATIONAL POLICY OF THE RESERVOIRS IN MALWATHU OYA RIVER BASIN TO MINIMIZE FLOOD DAMAGES IN ANURADHAPURA, VAVUNIYA AND MANNAR DISTRICTS IN NORTHERN SRI LANKA

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KeyWords: HEC-HMS Hydrological Modeling, Reservoir Operation, Malwattu Oya, Environmental Damage, Crop Production, River Analysis System.

ABSTRACT

The need for water is universal. It is present everywhere, and without water, life, as we know it, will simply cease to exist. Water is constantly in motion, passing from one state to another, and from one location to another, which makes its rational planning and management a very complex and difficult task under the best of circumstances. Water may be everywhere, but its use has always been constrained in terms of availability, quantity and quality. When the quantity of flood water released from the reservoirs in the upper catchment of Malwathu Oya river basin reaches a certain level, social, economic and environmental damages occurs to the people living in the downstream of the reservoir area. Further unplanned human activities in the Malwathu Oya river bank area create a threat on the natural bio diversity of the river. It is essential to create a master plan to in cooperate construction of buildings for various purposes, crop production, live-stock and tourism. To address these effects a study is being carried out. It gives a scientific emphasize on the necessity of modified / improved reservoirs operation.

1.0 INTRODUCTION

The Malwathu Oya river which is also called Aruvi Aru at the lower reaches has a total length of 162 km. It is the second largest river basin in Sri Lanka. It originates at Ritigala Hills (766 m MSL) in the North Central Province and flows to the sea at Arippu in Mannar District. About 70% of the upper catchment of Malwathu oya is located in the Anuradhapura District while the lower catchment is located in Vavuniya and Mannar Districts. Though it is the second largest basin, the amount of yield from the basin is not very large as it is located in the dry zone. The upper catchment of Malwathu Oya is intercepted by five major reservoirs, namely Nachchaduwa, Mahakanadarawa, Nuwarawewa, Tissa wewa and Pavatkulam together with a host of medium / minor tanks. Currently Nachchaduwa, Nuwarawewa and Tissa wewa irrigation schemes are augmented with Mahaweli water diverted from Kalaoya basin through Kala Oya Yoda Ela.

The lower part of the basin is very dry as it lies in a semi –arid zone where the average annual rainfall is around 1000mm. There are two ancient reservoirs in the lowest reach of the basin namely Giants tank and Akathimurippu tank in the right bank and left bank respectively of Malwathuoya. These two tanks are fairly shallow as they lie in a very flat terrain and have large water spread areas.

However in 2011/2012 and in December 2014 upper catchment of Malwathu Oya received comparatively high rainfall. Subsequently all the reservoirs started spilling and spill gates were opened according to the standing orders. Due to the accumulation of spill water of the major reservoirs in the basin, water level of Malwathu Oya increased unexpectedly. Due to this,

- Major part of Anuradhapura city went under water.
- Part of Vavuniya district specially Venkala Cheddikulam area inundated.
- Main land of Mannar District were severely affected as all flood water flows through this area even though it received not very high rainfall.

As a result, social, economic and environmental damages occurs to the people living in the area.

2.0 LITERATURE REVIEW

The specific objectives of this study are

- Demarcating the boundaries of water spread area along Malwathu Oya at selected locations with time of operation of the major reservoirs located at upper catchment of Malwathu Oya.
- Identifying the pattern of flood water with related to operation of major reservoirs during North East monsoon.
- Identifying cultivation programme / cultivation performance of all the reservoirs in the Malwathu Oya river basin.
- Tabulating a correlation between the flood water level at selected locations and the reservoir operations.
- Suggesting improved operational procedures for the major reservoirs.
- Demarcating differential flood zone in the Malwathu Oya river basin after regulating the operation of the major reservoirs.

3.0 LITERATURE REVIEW

3.1 River flow Management

Batalla (2000) says the effects of a given reservoir on flow regime will depend on its capacity in comparison with river runoff, its purpose (e.g. irrigation diversions, hydro electric generation, flood control), and its operating rules, precluding simple generalizations about the post-dam discharge distributions.

In the case of reservoirs built for flood control, a consistent relationship between degree of impoundment and change in flow variables can be expected. However, for reservoirs built for irrigation and hydroelectric generation, we should expect the relation to be noisy because flood reduction is not a purpose and the volume of floodwater stored will be a function of how much water happens to be in the reservoir when the flood begins (Walker, 1985). Floods will tend to be reduced more in dry years and early in the season, when reservoir levels are lower. Moreover, it can be expected that reservoir effects are more pronounced in drier climates because of greater storage needs and greater likelihood that the reservoir will be drawn-down when floods enter.

Andrés Calizaya (2010) pointed out that the Integrated Water Resources Management has been recognized worldwide as the only currently feasible way to ensure a sustainable perspective in planning and managing water resources systems. It is the main reference for all water related activities in third world countries. Sufficient water supply might be considered to be one of the most important factors for improving quality of life in these countries.

3.2 Methods for Flood Analysis

Pistocchi explained the model package “River Analysis System” (RAS) by the US Army Corps of Engineers – Hydrologic Engineering Center (HEC) includes:

- a steady flow model
- an unsteady flow model
- the consideration of a wide range of hydraulic works, bridges, storage areas
- facilities for hydraulic design such as computation of localized scour at the piles of a bridge

Due to its capability of describing that wide range of physical processes it has proven very helpful in supporting all phases of river management planning.

4.0 METHODOLOGY

4.1 Study area description

The Malvathu River (Sinhalese: මල්වතු ඔය Malvathu Oya, Tamil: அருவி அறு Aruvi Aru) is a 164 km (102 miles) long river in Sri Lanka, connecting the city of Anuradhapura, which was the capital of the country for over 15 centuries, to the coast of Mannar. It currently ranks as the second longest river in the country, with a great historic significance. The northern part of the river, and sometimes the whole river, was once been known as Aruvi Aru, given in Figure 4.1. The figure 4.2 shows the effect of heavy flood in the city of Anurathapura within the catchment of the Malwatta oya river basin.

4.2 Demarcating the boundaries of water spread area along Malwathu Oya at selected locations with time of operation of the major reservoirs located at upper catchment of Malwathu Oya.

Cross sections of water spread area at predetermined locations along Malwathu Oya is being collected using Digital Total Station and GPS. Spilling data and radial gate / flood gate operational data is collected from Irrigation Department.

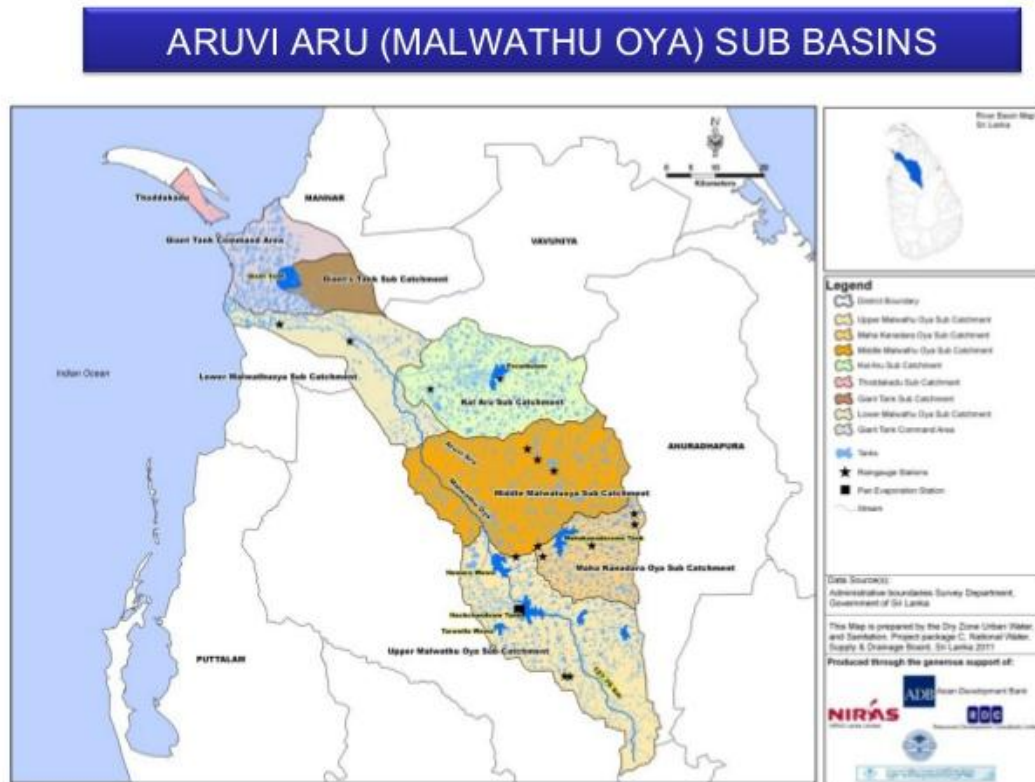


Figure 4.1. Study area – Malwathu Oya (Aruvi Aru) River Basin



Figure 4.2. Study area Anurathapura under flood in December 2014

4.3 Identifying the pattern of flood water with related to operation of major reservoirs during North East monsoon.

HEC-RAS model is being used to analyze the pattern of flood water with related to operation of reservoirs in the catchment of Malwathu Oya considering the existing reservoir network and the proposed reservoirs in near future which is shown in Figure 4.3 Considerable amount of water is transferred from Kala Oya basin to Malwathu Oya basin. This also will be considered in the flood water analysis.

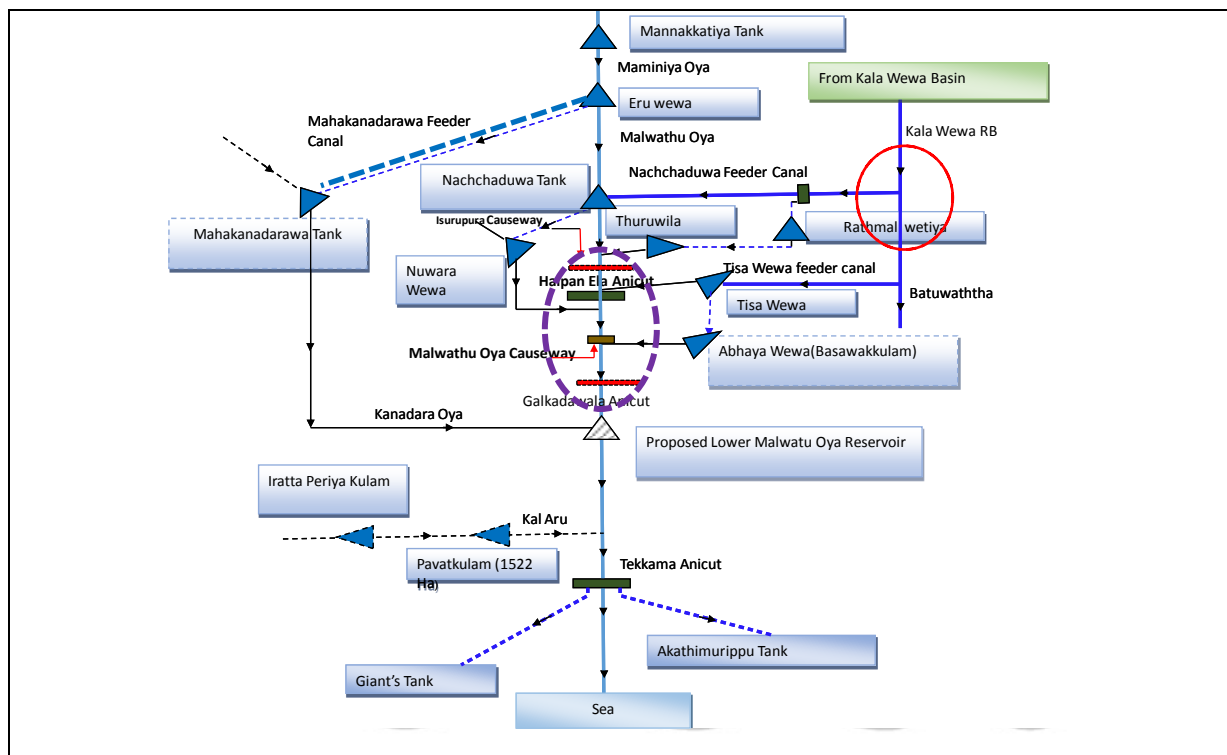


Figure 4.3. Main Reservoir network of Malwathu Oya river basin

4.4 Identifying cultivation programme / cultivation performance of all the reservoirs in the Malwathu Oya river basin.

Cultivation programme and cultivation performance of all major reservoirs for past 10 years are collected and the relationship between water level in the reservoirs during North East monsoon and the cultivation performance will be identified. This is used to identify the suggestion whether the reservoirs could be operated in a modified way to minimize the flood water levels in the downstream of reservoirs without affecting the cultivation performance.

4.5 Tabulating a correlation between the flood water level at selected locations and the reservoir operations.

Correlation between the flood water level at predetermined locations and the major reservoirs operation will be tabulated. Different scenarios will be considered to find out the minimum flood water level in the downstream of reservoirs. Modifications / improvements to existing standing orders also will be considered to find out the possibilities of minimizing the flood water level in the downstream of reservoirs specifically in Anuradhapura city, Venkala Cheddikulam area and main land of Mannar district.

4.6 Suggesting improved operational procedures for the major reservoirs.

Based on the results obtained above modified / improved operational procedures is being drafted suggested considering the entire major reservoir network and the cultivation performance?

4.7 Demarcating differential flood zone in the Malwathu Oya river basin after regulating the operation of the major reservoirs.

Inundation area with time of operation of reservoirs (spilling, radial gate / flood gate opening) is identified and marked in maps to provide advance information to general public and other interested parties.

5.0 DATA COLLECTION AND ANALYSIS

The following data are being collected for this research (for past 10 years)

- Daily Rainfall of upper catchment of Malwathu Oya river basin
- Daily water levels of the Major reservoirs in Malwathu Oya river basin
- Radial gates / flood gates opening of the major reservoirs
- Standing orders for operation of these major reservoirs during North East monsoon
- Cross section of Malwathu Oya at selected locations
- Flood level of Malwathu Oya during 2014 December in selected points
- Cultivation programmes and Cultivation performance of all the reservoirs in the Malwathu Oya river basin

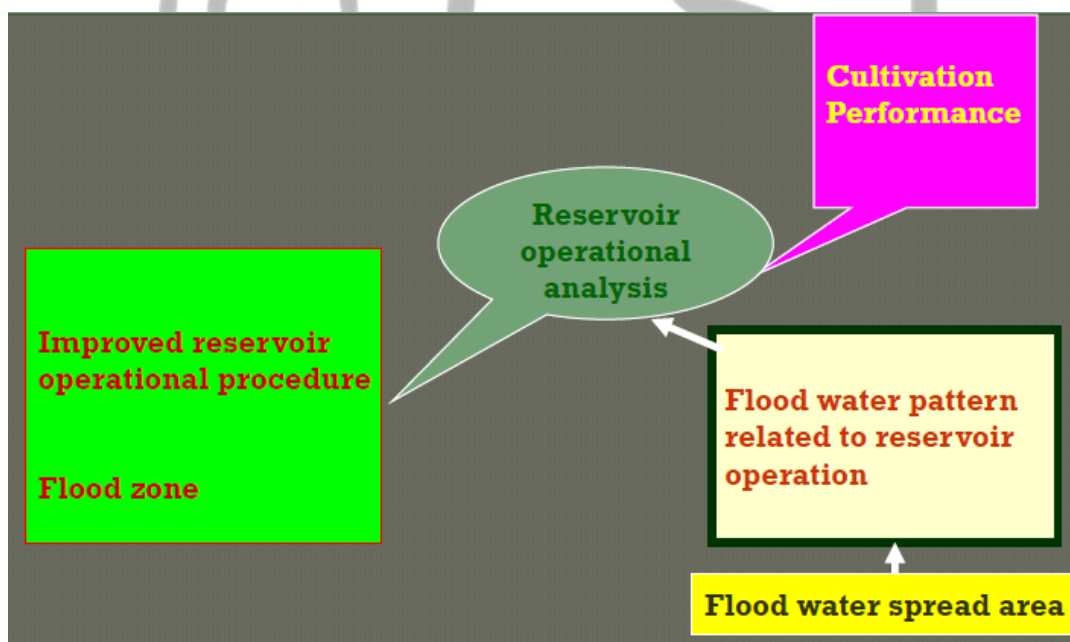


Figure 5.1. Schematic diagram of analysis

Flood water level analysis are carried out for predetermine sample points selected already. Data collected for past years are correlated with reservoir operation system. All these data are first analyzed for consistency and put in to the model formulated to get the good correlation. Formulated model to represent the reservoir operation in the entire river basin is calibrated and validated. This model is used for various studies related to reservoir operational strategy for different conditions.

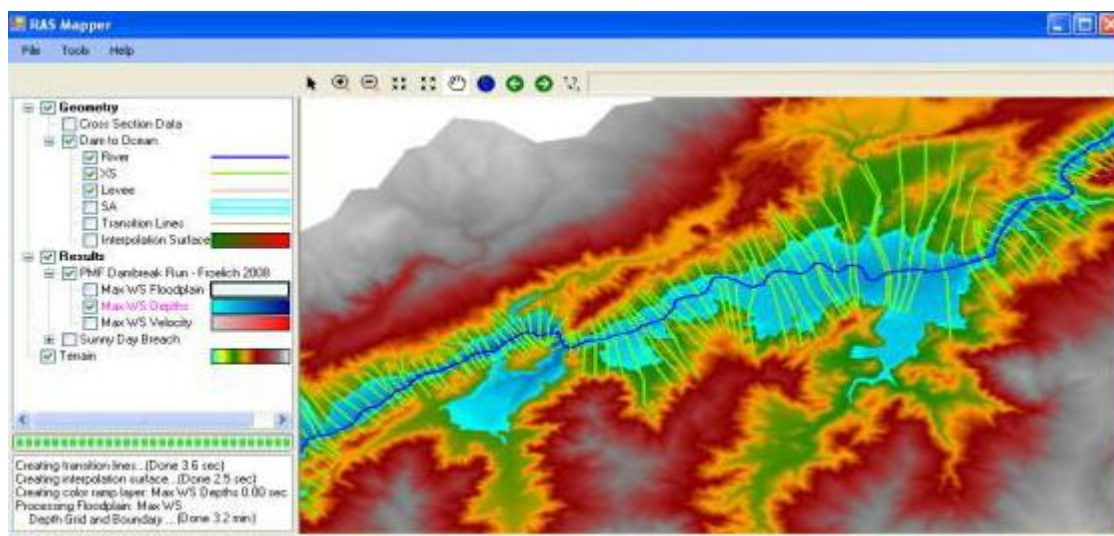


Figure 5. HEC-RAS model analyze the pattern of flood water with related to operation of reservoirs

6.0 RESULTS AND DISCUSSION

There is a direct relationship between the operation of major reservoirs in the upper catchment of Malwathu Oya and the level of water in Malwathu Oya during Norst East monsoon period. Finding the flood water level with time and the integrated operation of the major reservoirs will minimize flood damages in Anuradhapura, Vavuniya and Mannar Districts. The final results of the study will facilitate to understand the flood water level at selected locations along Malwathu Oya during North East monsoon. Through this study the importance of timely operation of radial gates / flood gates of the major reservoirs in the upper catchment of Malwathu Oya. Modification and improvements to the existing standing orders to the reservoir operation is suggested. Flood damages to the downstream of reservoirs will be minimized by understanding the reservoir operation considering integrated water resources management at river basin level. When the water resources are managed in the river basin level social, economic and environmental damages due to flood water will be minimized. Finally land and water productivity will be increased due to technically improved reservoir operation.

7.0 RESULTS AND DISCUSSION

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REFERENCE

1. Agarwal, A, "A Data model with pre and post processor for HEC-HMS", Report of Graduate Studies, Texas A & M Univ. College station, 2005
2. Andrés Calizaya, Oliver Meixner, Lars Bengtsson, Ronny Berndtsson, Multi-criteria Decision Analysis (MCDA) for Integrated Water Resources Management (IWRM) in the Lake Poopo Basin, Bolivia, *Water Resour Manage* (2010) 24:2267–2289, DOI 10.1007/s11269-009-9551-x
3. Chandrasekara, C.M.K.N.K., Weerasinghe, K.D.N., Ranjana, U.K., Piyadasa and Sumith Pathirana, 2014. Salinity, pH and Turbidity changes of water in the Negambo lagoon. *Colombo Arts. Journal of Social Sciences and Humanities*, pp. 1-11.
4. Chandrasekara, C.M.K.N.K., Weerasinghe, K.D.N., Ranjana, U.K., Piyadasa and Sumith Pathirana, 2014. Salinity, pH and Turbidity changes of water in the Negambo lagoon. *Colombo Arts. Journal of Social Sciences and Humanities*, pp. 1-11.
5. [Chong-yu Xu](#) Text book of hydrological model, Uppsala university department of earth science and Hydrology, 2002.
6. Columbus, N., 1965. Viscous Model Study of saltwater intrusion in water table aquifer. *Water resource research*, Issue 1.
7. Di Sipio, E., Galgaro, A., Rapaglia, J. and Zuppi, G., 2006. Salt water contamination on Venice lagoon mainland: New evaluation of origin, extension and dynamics. *Intrusion In Sedimentary Aquifers*, 25 September, pp. 195-204.
8. Diamantopoulou, E., Dassenakisa, M., Kastritisa, A., Tomarab, V., Paraskevopoulou, V. and Poulosb, S., 2008. Seasonal fluctuations of nutrients in a hypersaline Mediterranean lagoon. *Desalination*. Issue 224, pp. 271-279.
9. Dimuthu Daluwatte D., Sivakumar S S., "Community Based Organizations of Water Users and Factors Contributing for Functionality and Sustainability in Sri Lanka" *GSJ*: 11/2018; 6(11), pp 352-357 ISSN 2320-9186
10. Dimuthu Daluwatte D., Sivakumar S S., "Economic Loss of Fisheries Due to the Post Harvest Quality Loss and Assessment of the Quality Loss in Fish" *GSJ*: 9/2018; 6(9), pp 115-124 ISSN 2320-9186

11. Elham,R., Noredin,R., Shaharam,K.S., and Somaieh,T., 2012. Calibration of loss estimation methods in HEC-HMS for simulation of surface runoff (Case Study: Amirkabir Dam Watershed, Iran). *Advances in Environmental Biology*, VI(1), pp. 343-348.
12. Filhol,A.T.R,Furian,S.,Victoria,R.L.,Mascre,C.,Valles,V.and Barbiero,L., 2012. Hydrochemical variability at the Upper Paraguay Basin and Pantanal wetland. *Hydrol.Earth Syst.Sci.*, Issue 16, pp. 2723-2737.
13. Giada,F.,Valentina,C.and Vittorio,D., 2013. Saltwater Intrusion in Coastal Aquifers:A primary case study along the Adriatic coast investigated within a probabilistic framework. *Water*, 10 May, pp. 1830-1847.
14. Gowthaman, S., Mafizur, R., and Sivakumar, S.S., "Performance Evaluation of Waste Water Treatment Plant: an analysis of FOG removal efficiency" , *International Journal of Scientific and Engineering Research* 1/2017; 8(1): pp 2084-2089, ISSN – 2229 – 5518
15. Gunaratne,G.L.,Priyadarshana,T.,Manatunge,J.,Tanaka,N.and Yasuda,S., 2010. *Water balance and renewal time of Rekawa lagoon,Sri Lanka:A restorative approach..* Moratuwa: international Conference on Sustainable Built Environment.
16. H.K.S. Shanthasiri, R. Wijesooriya. "Case Study on Community Involvement in Rural Water Supply in Sri Lanka." Lao, 2004.
17. Hamseen, M.H.M. and Sivakumar,S.S., 2016. Water Conflict Resolution in Multiple User Senarios in Mahakanadarawa Scheme in Sri Lanka.. *International Journal of Scientific and Engineering Research*, 7(2), pp. 130-136.
18. Harun,A.,Huseyin,K.and Osman,E., 2015. *The salinity problem at Yelkoma lagoon(YUMURTALIK-ADANA) and its restoration by mixing with freshwater from ceyhan river.* Antalya,Turkey: Fresenius EnvironmentalBulletin.
19. Hicks, F.E., Peacock,T., Canadian Water Resources Journal Vol. 30(2): 159–174 (2005)
20. Hunter, P.R. "Climate change and waterborne and vector-borne disease." *Applied Microbiology* 94, no. 1 (2003): 37-46.
21. Janen, S.S., .and Sivakumaer,S.S., 2014. Ground Water Quality Improvement of Jaffna Peninsula of Sri Lanka by Regulating Water flow in the lagoon Mouths.. *International Journal of Scientific & Engineering Research*, Issue 5, pp. 973-978.
22. Janen, S.S., .and Sivakumaer,S.S., Sustainable Community Project Identification and Selection Based on the Experience Gained from Emergency Northern Recovery Project, Proceedings of International Conference on Contemporary Management-2014(ICCM-2014), Vol.1, pp 962-968, Faculty of Management Study, University of Jaffna Publication, ISSN – 2362 – 0536
23. Janen,S.S. and Sivakumaer,S.S, 2014. Ground Water Quality Improvement of Jaffna Peninsula of Sri Lanka by Regulating Water flow in the lagoon Mouths.. *International Journal of Scientific & Engineering Research*, Issue 5, pp. 973-978.
24. Janithra S., Pratheeba J., Athapattu B C L., Sampath D S., Sivakumar S S., "Investigate the Post War Improvements of Hydraulic infrastructure in Irrigation Systems of Kanagarayan Aru River Basin Using Hydrological Model" GSJ: 12/2018; 6(12) , pp 397-405 ISSN 2320-9186
25. Jason T. Needham, David W. Watkins Jr., Jay R. Lund, S. K. Nanda, Linear Programming for Flood Control In The Iowa And Des Moines Rivers, *Journal of Water Resources Planning and Management*, May/June 2000
26. Jenicek,J., 2008. *Modelling the effect of small reservoirs on flood regime in the Chomutovka river basin.* Prague: 24th conference of the Danubian countries on the hydrological forecasting and hydrological bases on water management.
27. Kähköne, Satu. "Does Social Capital Matter in Water and Sanitation Delivery" 9. World Bank, 1999.
28. Kirshanth, L., and Sivakumar, S.S. "Optimization of Water Resources in the Northern Province River Basins for Irrigation Schemes Used for Food Production in Sri Lanka" *International Journal of Scientific and Engineering Research* 7/2018; 9(7): pp 569-573, ISSN – 2229 – 5518
29. Kotagama, S. W. ,Bambaradeniya, C.N.B., 2006. *An Overview of the Wetlands of Sri Lanka and their Conservation Significance.* Colombo, Sri Lanka: The Central Environmental Authority (CEA), The World Conservation Union (IUCN) and the International Water Management Institute (IWMI).
30. Kuganesan,S. and Sivakumar,S.S, 2016. River for Jaffna-Cultivating Productive water from Saltwater Lagoons in Northern Sri Lanka-What the Water Balance of Elephant Pass Lagoon Demonstrates. *International Journal of Scientific and Engineering Research*, 7(2), pp. 137-142.
31. Kuganesan,S. and Sivakumar,S.S., 2015. Hypothesis of Cultivating Productive Water from Lagoons of Northern Sri Lanka.. *International Journal of Advanced Research*, 3(9), pp. 637-345.
32. Kularam,S.,Thushyanthy,M., and Sivakumar, S.S., 2016. Importance of rehabilitation and Reconstruction of Irrigation Infrastructure, before the Introduction of pedma Cultivation under Iranamadu Irrigation Scheme of Northern Sri Lanka. *International Journal of Scientific and Engineering Research*, 7(7), pp. 288-293.
33. LOICZ, 2005. Land ocean interactions in the coastal zone. In: H. T. Kremer, ed. *Science plan and implementation strategy.* s.l.:IGBP Report51/IHDP Report 18, p. 68.
34. M. W. C. Dharma-wardana, Sarath L. Amarasiri, Nande Dharmawardene, C. R. Panabokke. "Chronic kidney disease of unknown aetiology and ground-water ionicity: study based on Sri Lanka." *Environmental Geochemistry and Health* 37, no. 2 (2015): 221-231.
35. Mitsch,W.J. and Gosselink,J.G., 2008. *Wetlands.* 4th ed. New York: John Wiley & Sons.
36. Mudge,S.M.,Icely,J.D. and Newton,A., 2008. Residence time in a hypersaline lagoon:Using salinity as a tracer. *Estuarine,Coastal and ShelfScience*, Issue 77, pp. 278-284.
37. Navaneethakrishnan,S., and Sivakumar, S.S., 2015. Bibliometric Analysis of Water Resource Development and Utilization Based Research Studies in Sri Lanka. *International Journal of Scientific and Engineering Research*, 7(8), pp. 1432-1439.
38. Navaratnarajah, V., 1994. *Water Problems in the Jaffna Peninsula.Affordable Water Supply and Sanitation.* Colombo,Sri Lanka, 20th WEDC Conference.
39. Newton,A. and Mudge,S.M., 2003. Temperature and salinity regimes in a shallow,mesotidal lagoon,the Ria Formosa,Portugal.. *Estuarine,Coastal and ShelfScience*, Issue 57, pp. 73-85.
40. Nirojan, K., Subramaniam, D.N., and Sivakumar, S.S., "Challenges in Utilization of Potential Groundwater and the Hypotheses of River for Jaffna for Cultivating Productive Water" , *International Journal of Scientific and Engineering Research* 10/2016; 7(10): pp 768-774, ISSN – 2229 – 55181
41. Nitharsan, U., Anusuthan, N., Thinojah, T., Mafizur, R., and Sivakumar, S.S., 2017. Freshwater Cultivation by Continuous Flushing of River Water through Elephant Pass Lagoonto Vadamarachchi Lagoon in Northern Sri Lanka. *International Journal of Scientific & Engineering Research*, 8/2, pp. 705-710.
42. Pistocchi, A., Mazzoli, P., Use of HEC-RAS and HEC-HMS models with ArcView for hydrologic risk management
43. Ponrajah, A., 1984. *Design of Irrigation Headworks for Small Catchments.* 2nd ed. Colombo: Colombo Irrigation Department.

44. Praveen,R.,Kalpesh,B.,and Manekar,V.L., 2015. *Simulation of Rainfall Runoff Process using HEC- HMS (case study:Tapi River,India)*. IIT Roorke: HYDRO 2015 INTERNATIONAL.
45. Priyadarshana,T.,Manatunge,J.,Tanaka,N.and Yasuda,S., 2010. Water balance and renewal time of Rekawa lagoon,Sri Lanka;A restorative approach.. Moratuwa: international Conference on Sustainable Built Environment.
46. Ramon J. Batallaa,, Carlos M. Gomez, G. Mathias Kondolf (2004), Reservoir-induced hydrological changes in the Ebro River basin (NE Spain), *Journal of Hydrology* 290, 117-136.
47. Rapaglia,J. Di Sipio,E., Galgaro,A., and Zuppi,G., 2006. Salt water contamination on Venice lagoon mainland:New evaluation of origin,extension and dynamics.. *Intrusion In Sedimentary Aquifers*, 25 September, pp. 195-204.
48. Ravi, V., Hareth, G.B.B., Manobavan, M., and Sivakumar, S.S., 'An Assessment of Ground Water Quality in Selected Dug Wells in Vavuniya Urban Council Limit through Water Quality Index' *International Journal of Scientific and Engineering Research* 04/2016; 7(4): pp1517-1526, ISSN – 2229 – 55181
49. Ravi, V., Hareth, G.B.B., Manobavan, M., Sivakumar, S.S., 'Management Plan to Reduce the Adverse Effects of Proximity of Dug Wells and Septic Tanks in Urban Area to Diminish Coli form Contamination' *International Journal of Scientific and Engineering Research* 03/2016; 7(3): pp507-513, ISSN – 2229 – 5518.
50. Se-Yeun Lee, Alan F. Hamlet, Carolyn J. Fitzgerald, Stephen J. Burges, Optimized Flood Control in the Columbia River Basin for a Global Warming Scenario, *Journal of Water Resources Planning and Management*, November/December 2009
51. Shaharam,K.S.,and Somaieh,T., 2012. Calibration of loss estimation methods in HEC-HMS for simulation of surface runoff (Case Study: Amirkabir Dam Watershed, Iran). *Advances in Environmental Biology*, VI(1), pp. 343-348.
52. Sivakumar, S.S., (2002). Water resource development strategy of North East 2002/2012.
53. Sivakumar, S. S., "Ground Water Quality Improvement of Jaffna Peninsula of Sri Lanka by Regulating Water Flow in the Lagoon Mouths", *International Journal of Scientific and Engineering Research*, 04/2014; 5(4), pp973-978, ISSN – 2229 – 5518
54. Sivakumar, S.S., 'Flood Mitigation Strategies Adopted in Sri Lanka A Review' *International Journal of Scientific and Engineering Research* 03/2015; 6(2):pp607-611, ISSN – 2229 – 5518
55. Sivakumar, S.S., (2002), Water Resources and Agriculture Development Strategy North East Province Volume 1 & 2.
56. Sivakumar, S.S., 'Irrigation Scheme Development and Management Strategy for Conflict Affected Northern and Eastern Province of Sri Lanka' *International Journal of Scientific and Engineering Research* 08/2015; 6(8): pp1004-1008, ISSN – 2229 – 5518.
57. Sivakumar, S.S., "Conjunctive Use of Surface and Groundwater for Economic Food Production", *Voice for Change-Journal of Jaffna Managers Forum* pp149-154, ISBN 978-955-4760-00-4 (2013)
58. Sivakumar, S.S., "Conjunctive Use of Surface and Groundwater to Improve Food Productivity in the Dry Zone Area", *ENGINEER, Journal of Institution of Engineers Sri Lanka*, Vol;XXXVI, No.01, pp 21-29,January 2013, ISSN 1800-1122
59. Sivakumar, S.S., "Development Strategy and Food for Taught in Water and Agriculture Sector of Re-Emerging Conflict Affected Northern Sri Lanka", *Transaction of Institution of Engineers Sri Lanka Northern Provincial Centre* 09/2014; Session 2013/2014:29-52.
60. Sivakumar, S.S., "Effective Utilization of Available Water Resource by Following Proper Irrigation Practices in Sri Lanka", *International Journal of Scientific and Engineering Research*. 08/2014; 5(8):210-215, ISSN – 2229 – 5518.
61. Sivakumar, S.S., "Management Policy of Water Table in Dry Zone of Sri Lanka to Subsidise the Pain of Non Rice Crop Cultivators for the Food Productivity Improvement", *RJSITM, The International Journal Research Publications*, Volume 02, Number 09, pp. July-2013, ISSN:2251-1563
62. Sivakumar, S.S., "Policy alternatives of the management of minor and medium irrigation schemes to develop groundwater system in restricted catchments for the improvement in food productivity in the dry zone of Sri Lanka. *Proceedings of National Conference on Water*", Food Security and Climate Change in Sri Lanka Vol. 3, Page 73-88 (2009) *IWMI Publication* ISBN 978-92-9090-720-6
63. Sivakumar, S.S., "Post Conflict Development Strategies. 2012: Emergency Northern Recovery Project".
64. Sivakumar, S.S., "Reclamation of Land and Improve Water Productivity of Jaffna Peninsula of Northern Sri Lanka by Improving the Water Quality of the Lagoons" *RJSITM*. 2(08): p. 20-27.
65. Sivakumar, S.S., "Strategies for Catchment Development Master Plan and Economic Aspects of Water Resource Planning" *International Journal of Scientific and Research Publications* 07/2014; 4(7):1-5.
66. Sivakumar, S.S., "Strategy to be adopted in Preparation of National Water Resource Master Plan", *International Journal of Scientific and Engineering Research*. 06/2014; 5(6): pp578-591, ISSN – 2229 – 5518.
67. Sivakumar, S.S., "Water Management Strategies to be adopted in Sri Lanka to Improve Food Productivity to Accommodate the Population Growth", *International Journal of Advancements in Research & Technology*. 05/2014; 3(5):pp207-211, ISSN 2278 – 7763.
68. Sivakumar, S.S., "Water Resource and Agriculture Development Strategy-North East Province 2002/2012" Vol. 2. 2002: Irrigation Department.
69. Sivakumar, S.S., "Water Resource and Agriculture Development Strategy-North East Province 2002/2012" Vol. 1. 2002: Irrigation Department.
70. Sivakumar, S.S., "Water Utility and Management Policy for Effective Sharing of Natural Water Resource in the Costal Dry Zone of Sri Lanka in the North East Region". *ENGINEER, Journal of Institution of Engineers Sri Lanka*, Vol;XLVII, No.01, pp 37-42,January 2014, ISSN 1800-112
71. Sivakumar, S.S., Alternate management options of small scale surface water resource system to develop ground water system for the improvement in food productivity in Dry Zone of Sri Lanka. *Proceedings of Workshop on Challenges in Groundwater Management in Sri Lanka*. P63-72 (2011)
72. Sivakumar, S.S., Application of Electronic Spread Sheet and Water Balance Error Optimization Technique in Ground Water Model Study to Improve the Ground Water System in Restricted Area, *International Journal of Advanced Research*. 07/2014; 2(6): pp792-808, ISSN 2320 – 5407.
73. Sivakumar, S.S., *Conjunctive Use of Surface and Groundwater to Improve Food Productivity in Restricted Ares*. 2008, University of Moratuwa, Sri Lanka.
74. Sivakumar, S.S., *Conjunctive Use of Surface and Groundwater to Improve Food Productivity in the Dry Zone Area*. *ENGINEER, Journal of Institution of Engineers Sri Lanka*, Vol;XXXVI, No.01, pp 21-29,January 2013, ISSN 1800-1122
75. Sivakumar, S.S., *Engineer's Roll in Sustainable Recovery Process of Post (Natural) Disaster*. *Proceedings of International Conference on Contemporary Management-2014(ICCM-2014)*, Vol.1, pp 947-954, Faculty of Management Study, University of Jaffna Publication, ISSN – 2362 – 0536

76. Sivakumar, S.S., Groundwater balance study in a restricted catchments in Vavuniya to find effective recharge location by introducing new operational policy on minor / medium irrigation schemes. Seminar on Irrigation for the Centenary programme of Irrigation Department, P163-174(2001)
77. Sivakumar, S.S., Policy alternatives of the management of minor and medium irrigation schemes to develop groundwater system in restricted catchments for the improvement in food productivity in the dry zone of Sri Lanka. Proceedings of National Conference on Water, Food Security and Climate Change in Sri Lanka Vol. 3, Page 73-88 (2009) IWMI Publication ISBN 978-92-9090-720-6
78. Suthaharan, N., Ketheesan, B., Ratnaweera, H.C., and Sivakumar, S.S., "Challenges in Utilizing Water Resources in Lower Reaches of Kanakarayanaru of Northern Sri Lanka for Efficient and Equitable Water Allocation" , International Journal of Scientific and Engineering Research 7/2018; 9(7): pp 821-826, ISSN – 2229 – 5518
79. Tett, P., Gilpin, L., Svendsen, H., Erlandsson, C.P., Larsson, U., Kratzer, S., Fouilland, E., Janzen, C. and Scory, S., 2003. Eutrophication and some European waters of restricted exchange.. *Continental Shelf Research*, Issue 23, pp. 1635-1671.
80. Tharmendra, P., Sivakumar, S.S., 'Organizational Management of Groundwater by Farmers for the Sustainable Utilization of Water Resource in Jaffna District of Northern Sri Lanka' International Journal of Scientific and Engineering Research 01/2016; 7(1): pp944-948, ISSN – 2229 – 5518
81. Thileepan, K., and Sivakumar, S.S., "Impact of Water Resource Auditing - Intergrated Development Approach - to Mitigate Water Related Disasters in the Vavuniya Divisional Secretariat's Division in Northern Sri Lanka" , International Journal of Scientific and Engineering Research 8/2018; 9(8): pp 43-49, ISSN – 2229 – 5518
82. Thinojah, T., and Sivakumar, S.S., "Water Resource Development in Jaffna Peninsula" Transactions of Institution of Engineers Sri Lanka, Northern Chapter 11/2016; Session 2015/2016:70-71.
83. V.Tyriakidis, R.K.Guganesharajah, S.K.Ouki, "Groundwater potential in the Jaffna Peninsula and impacts of climate change," International conference on Water resources development sanitation improvement, 01 August 2009.
84. Valentina, C. and Vittorio, D., 2013. Saltwater Intrusion in Coastal Aquifers: A primary case study along the Adriatic coast investigated within a probabilistic framework. *Water*, 10 May, pp. 1830-1847.
85. Victoria, R.L., Mascre, C., Valles, V. and Barbiero, L., 2012. Hydrochemical variability at the Upper Paraguay Basin and Pantanal wetland. *Hydrol. Earth Syst. Sci.*, Issue 16, pp. 2723-2737.
86. Vijakanth, V., Sivakumar, S.S., and Ratnaweera, H.C., "Water Availability Study of Groundwater in Jaffna Peninsula of Northern Sri Lanka" , International Journal of Scientific and Engineering Research 1/2017; 8(1): pp 1563-1567, ISSN – 2229 – 5518
87. Visnuvarthanan, N., Sivakumar, S.S., 'Cultivating Productive Water in Valukai Aru Catchment in Valikamam Division of Jaffna District of Northern Sri Lanka' International Journal of Scientific and Engineering Research 01/2016; 7(1): pp1045-1048, ISSN – 2229 – 5518
88. Walker, K.F., 1985. A review of the ecological effects of river regulation in Australia. *Hydrobiologia* 125, 111-129.
89. Whiting, G. and Chanton, J., 2001. Greenhouse carbon balance of wetlands: methane emission versus carbon sequestration. *Tellus B*, Issue 53, pp. 521-528.
90. Wijenayake, T., 2013. NewsLanka. 'A River for Jaffna' project Envisages Conversion of Jaffna Lagoon into a Freshwater Lake, 12 September, pp. 14-24.

