Agro-well Development and its Impact on *Gasgommana* Tank Reservations in Tank Cascades of Sri Lanka

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Abstract

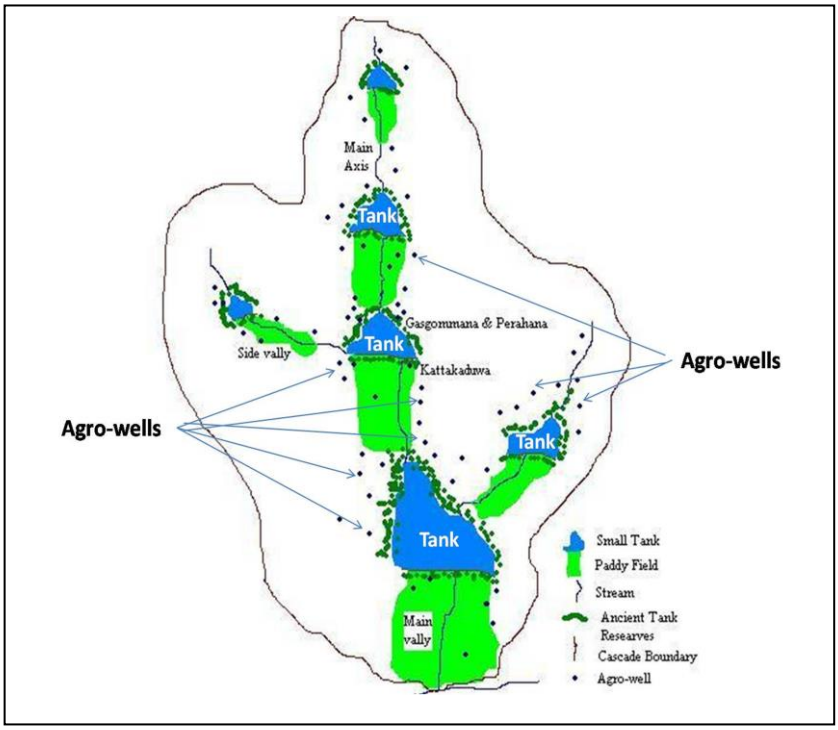
The expansion of Agro-well based agricultural systems has been a significant trend in the agricultural sector during the last three decades in the Dry Zone of Sri Lanka. Although there are many positive impacts, it has an adverse effect on tank reservations including natural vegetation belt locally called *"Gasgommana"* located surrounding the tanks. These systems have been contributing a lot of hydro-ecological services in tank cascades. Due to this recent issue on degradation of *Gasgommana* tank reservation, a study was planned to examine the impact on this tree zone using six tank cascades covering two river basins in the dry zone of Sri Lanka. For this study Geo-Eye 1 satellite images, Google images, direct observations, field surveys, structured questionnaire and focus group discussions were used for gathering necessary data. It was revealed that, with the increase of Agro well density in tank cascades, number of Agro-wells in reservations has been increased. In addition to the Agro-well excavation in reservations, these systems have been damaged due to Agro-well based land development, collection of woody materials and use of excavation machines. During the study, only 18 tree species were recorded in the remaining *Gasgommana* reservation area. It is also an evident that the tree density of *Gasgommana* reservation has decreased. With the increase of Agro-well density more than 15 per/ha, the *Gasgommana* land strips have also faded away nearly more than 60%.

Keywords: Agro-well development, Tank reservations, *Gasgommana*, Groundwater, Tree density

Introduction

Historically, the land use pattern of the tank cascades[1]in the dry zone of Sri Lanka has been transformed from natural ecosystem into agro-ecosystem. The traditional process of integrated forest and water resources management has reflected some sort of land allocations like 'Tank Reservations' within the tank cascades in the dry zone. The existence of these reservations has been challenged by the recent development activities within tank cascades. A number of researches including Dharamasena (1998), Dharmasena and Goodwill (1999), Senaratne (2002), Panabokke (2002), Pathmarajah (2002), Kikuchi *et al.*, (2003) and Perera and Nianthi (2016), (2017a) have reported the recent Agro-well development[2] in the vicinity of tanks (Figure 1).

Figure 1: Typical tank cascade system with emegence of Agro-wells



[1] Connected series of tanks with micro catchments and command areas, organized within a small valley.

[2]Agro-well development denotes both expansion of Agro-well constructions and Agro-well based land development.

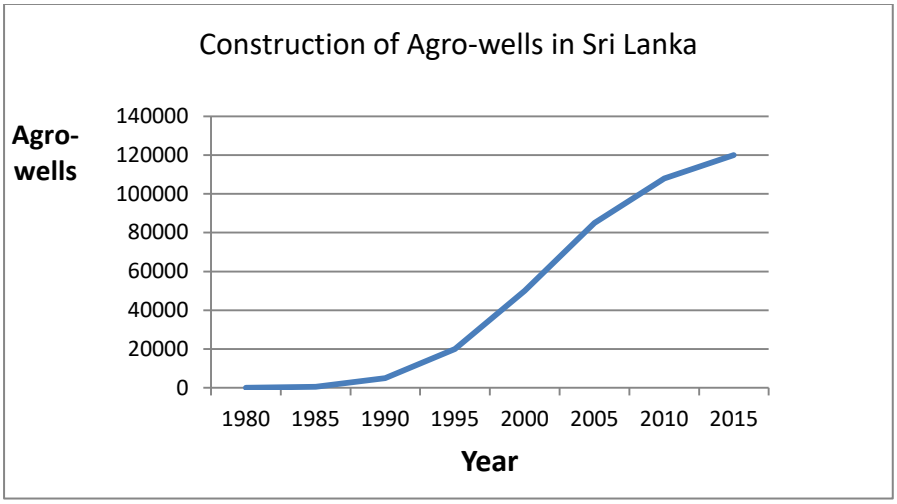
The topography of the tank cascade areas of the central dry zone consist of a thin weathered soil zone which appears to overlain by a thin alluvium layer in the lower and middle parts of the small valleys that consist of small tanks. This weathered bedrock is the aquifer which serves as the groundwater reserves for Agro-well irrigation (Dharmasena and Goodwill, 1999).

However, the rate of construction of Agro-wells to use shallow groundwater has been accelerated with the intervention of the Agricultural Development Authority (ADA) and the Provincial Councils since 1989 (Pathmarajah, 2002).Kikuchi *et al.* (2003) emphasized that the Agro-well development especially in minor irrigation schemes or in the small tank environments has been very rapid, and that has again been confirmed by Wijesundara, Nandasena and Jayakody (2012). A number of studies such as Dharmasena (1998), Aheear and Ariyabandu (2002), Pathmarajah (2002), Kikuchi *et al.* (2003),and Jinapala *et al.* (2012), have proven that the Agro-well based agriculture is economically profitable. However, currently there are more than 120,000 Agro-wells in Sri Lanka (Figure 2 & 3). The diffusion of Agro-wells has been very significant in the vicinity of small tanks in the dry zone due to easy access to the shallow aquifers and maintaining the ground water level closer to the land surface, even in the dry season.

Figure 2: Agro-well construction and land development

Source: Field Studies, 2015

Figure 3: Agro-well construction in Sri Lanka



Source: Author

The first attempt of the biological analysis of the tank is found in the Ratnatunga's (1970) "Eco-Village" concept to describe the Ecological /Biological status of tanks in the dry zone areas of Sri Lanka. Madduma Bandara (2010) explained, that "the traditional village tank systems in Sri Lanka support biodiversity as they provide mixed, heterogeneous landscapes: small tanks, irrigated paddy fields, forests, and villages in small areas". According to several studies, including Dharmasena (2004,2010), Perera (2010), Marambe *et al.* (2012), the tank ecosystems play a vital role such as maintaining the biodiversity, providing wiled fruits, protecting herbal plants, and supplying handloom materials including mat-grass and rattan in addition to maintaining the water source habitat units for a number of fauna species. Further, the ancient systems could provide valuable insights for making the present-day tank ecosystems sustainable and attractive. Poor understanding on the function of this complex ecosystem had led to either ignorance or inadvertent destruction of the ancient tank systems through various development projects (Marambe *et al*. 2012).

Forest reservations including stream reservation sand tank reservations are important components in a tank cascade and these have been providing various hydro-ecological services.There were several types of tank reservations with multiple scientific values, around the tanks and these reservations are surviving up-to-date for several centuries (Dharmasena 1998, Maddumabandara 2010, Perera 2017b, Perera 2017c).

Tank reservations are very important land uses with hydrological, ecological and technical values in the dry zone landscape. These reservations are known as "*Kattakaduwa*" (reserved land strip with well-rooted trees located between the tank bund and the paddy field),"*Perahana*" (strip of bushes in the immediate catchment and acts as a filter to the tank) and "*Gasgommana*" (strip of large trees located in the tank catchment). The *Gasgommana* lies, just above the water level of the tank in the catchment, serving as a windbreak, thus reducing evaporation losses. Between 10 - 20% of the small tank water surface has been covered by this forest patch (Perera 2017b) contributing to reduce the potential evaporation. This tree zone is very important in the dry and intermediate zones, to have an adequate supply of water, through minimizing the evaporation, as evaporation is high during the last two third of the cropping season. The indirect ecosystem functions of these reservations are the conservation of biodiversity, supplying medicinal plants, fuel woods, wild fruits and carbon sequestration in the forests.

There are about 16,000 tanks in Sri Lanka and 98% of them belong to small tank category (Perera, 2010).The estimated extent of tank reservations around small tanks varied from 0.2 ha to 11 ha, around medium tanks 02 ha - 20 ha and around Large tanks as10 ha - 250 ha (Figure 4 & 5).Accordingly, there may be 20,000- 25,000 ha of tank reservations in Sri Lanka.

Figure 4: G*asgommana* reservation

Source: Google images 2012 Imagery date 05/07/2012

Figure 5: Different forms of *Gasgommana* tank reservations

However, there is a legislative support to protect these systems at national level as follows.
According to the Agrarian Services Act (1979) and the Agrarian Service Revised Bill 2006-43-1,

i. Tank reserves should not be cultivated
ii. The destruction of the tree covers or soil erosion prone activities in an irrigation reserve or in a water source should be avoided.

According to the Agrarian Development Act, No. 46 of 2000 and the National Land Use Policy (Drafted in 2006) -iii – 7,

i. The reservations of all natural and man - made water courses and sources whether private or state will be demarcated and protected through appropriate conservation measures.

All this background has been developed a platform to examine the current issue on Agro-well development in tank cascades and its impact on the *Gasgommana* reservation area.

Methodology

Six sample tank cascades were selected for this study, covering upper Malwathu Oya Basin and upper Yan Oya basin in the North Central Dry Zone of Sri Lanka. The strategy was to examine the availability of tree species in *Gasgommana* reservations and correlated the findings with different Agro-well density values of tank cascades. Then *Gasgommana* tree zones of upper most tanks and lower tanks were selected, to cover the upper areas as well as lower areas within a tank cascade, for the tree survey.

To extract the information on Agro-wells construction in tank reservations of the study area, the Geo-Eye 1 satellite images (Geo Eye 1 – 2012 – 0.5m high resolution exclusive images) and Google images were observed first. Then the field verifications with the assistance of key farmers in each tank cascade were made for the final data base.

The second field study was undertaken to find out the tree density of each tank reservation. Following the standard criterion, the category of "trees" (Trees = Height = >1 m & DBH = > 5 cm), was selected for the floral survey. This survey was conducted as a field level tree census in tank reservations with five senior farmers. In addition to that, in-depth field observations, structured questionnaire and focus group discussions were also used to gather necessary data. Six focus group discussions were

conducted covering six tank cascades and 10-15 outstanding farmers representing lower, middle and upper parts of the cascades. Area calculations were completed with GIS maps, based on Geo Eye 1 satellite images, to find out the size of the cascades and *Gasgommana*area. Then the survey on tree density of the respective reservations was computed. In addition to that map interpretations, density calculations and correlations were used for the necessary analysis.

Results and Discussion

The tree survey was conducted in 6 tank cascades covering upper and lower tank *Gasgommana* reservations. Agro-well availability in reservations, Agro-well density of cascades as well as tree density of reservations was examined. Ahead of the tree survey, it was verified that no outstanding relationship of tree density of reservations with population density of cascades and other development activities. According to the survey, only 18 tree species were recorded and abundance species were *Damba,Kumbuk, Nabada* and *Nithul* (Table 1).

Table 1: Recorded Tree Species in *Gasgommana* reservation area

Local or Common Name	Scientific Name
Bakmee	*Nauclea orientalis*
Bo	*Ficus religiosa*
Damba	*Syzygium assimile*
Halamba	*Mitragyama parvifolia*
Karanda	*Pongamiapinnata*
Ketakala	*Bridelia retusa*
Kirikon	*Walsura trifoliolata*
Kohomba	*Azadirachta indica*
Kon	*Schleichera olesa*
Kumbuk	*Terminalia arjuna*
Lunuwarana	*Crateva adansoni*
Maila	*Bauhinia racemosa*
Mee	*Madhuca loggifolia*
Nabada	*Vitex leucoxylon*
Nithul	*Streblus asper*

Palmaira	*Borassusflabellifer*
Palu	*Manilcara hexandra*
Thimbiri	*Diospyros malabarica*

Source: Field survey 2013

Agro-well density of sample tank cascades was between 1.8 – 22 per sq.km. The tree survey was undertaken to examine the relationship between the Agro-well density of tank cascades and tree density in *Gasgommana* of each cascade. The highest tree density in *Gasgommana* area (57 per ha) was identified in the lowerst Agro-well density cascade (Rambewewa = 1.8 Per/km^2), while the lowest tree density (10 per ha) was reported in the highest Agro-well density cascade (Table 2).

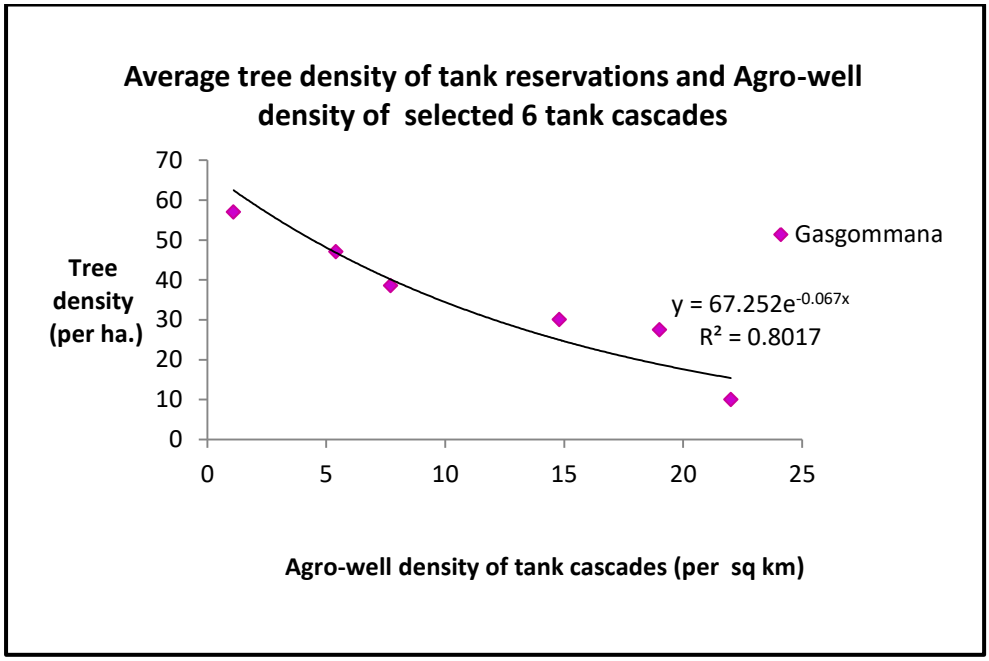
Table 2: Tree density of *Gasgommana* tank reservations

No	**Tank cascade**	**Agro-well density** (Per/km^2)	**Tank (upper tank & lower tank of the cascade)**	**Number of trees in *Gasgommana* Area**	**Extent of the *Gasgommana* (ha)**	**Density of trees in *Gasgommana* area (Per ha.)**	**Average Tree Density in Gasgommana (Per ha.)**
1	Periyakulama	22.0	Padiketuwewa	26	3.70	7	10
			Periyakulama	96	7.50	13	
2	Konwewa	14.8	Mawathawewa	98	3.10	31	30
			KonWewa	108	3.68	29	
3	Halmillawewa	5.4	IhalaHalmillawewa	362	7.00	52	47
			Halmillawewa	254	6.12	42	
4	Belikulama	19.0	Kawarakkulama	67	2.56	26	27
			BeliKulama	290	9.90	29	
5	Dambagaswewa	7.7	Pathirathnewewa	28	0.66	42	38
			Dambagaswewa	102	2.90	35	
6	Rambewewa	1.8	IhalaRambewewa	440	6.60	67	57
			Rambewewa	512	10.8	47	

Source: Field survey 2013 and GIS calculations based on Geo Eye 1 satellite images, 2012

Then average tree density value of each tank cascade, correlated with the Agro-well density. The results showed that the tree density of *Gasgommana* has been decreased with the increase of Agro-well density (Figure 6).Further, tree density of *Gasgommana* has been reduced with strong correlation ($R^2 = 0.801$) due to extracting poles and woody parts to fulfill the Agro-well based agricultural needs. That mean especially the tree density of *Gasgommana* has been affected due to the Agro-well constructions in or near to the tank reservations.

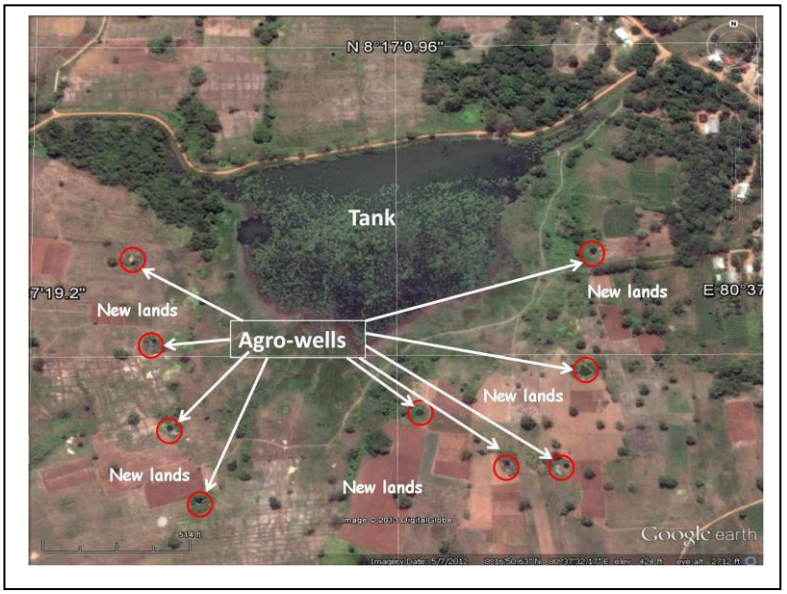
Figure 6: Relationship between the tree density of tank reservations and Agro-well density



In addition to the Agro-well availability in reservations, physical damages to the reservations were recorded due to the construction of Agro-wells using excavation machines and with the land clearing process. Further, thinning of trees in reservation areas was also observed. The reason was that hundreds of poles and other woody parts have been collected for Agro-well based agriculture especially for constructing huts and fence as well to construct beetle beds, bitter gourds and snake gourds

beds. Finally most of the areas of *Gasgommana* reservation has been damaged (Figure 7).

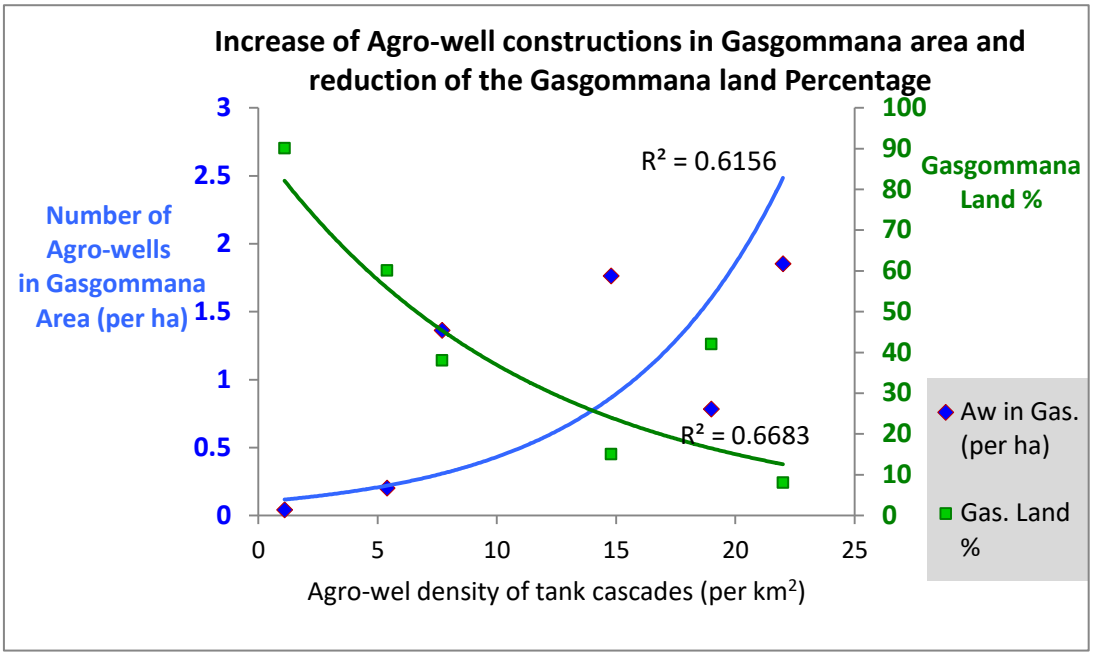
Figure 7: *Gasgommana* reservation damages due to Agro-well development



Source: Geo Eye 1 satellite images 2012 and Field survey 2013

Eventually the tree density also has been reduced, with this context. To analyze the spatial impact, the tree survey data and Agro-well data correlated with the Agro-well density of cascades. The analysis revealed that the *Gasgommana* land percentage has decreased more than 60 % with the increase of Agro-well density in tank cascades nearly more than 15 per/ha. Further, Agro-well density within *Gasgommana* area has also increased with the increase of Agro-well density of the same tank cascades (Figure 8).

Figure 8: Relationship between Agro-well construction and *Gasgommana* land cover



Source: Field survey 2013

Accordingly, the results revealed that with the expansion of Agro-wells up to tank reservation areas, the *Gasgommana* reservation has been affected by several ways.

Conclusion

Agro-well development in the dry zone of Sri Lanka has been spread out up to tank reservation areas of tank cascades. It was revealed that, although there were relevant regulations, Agro-wells have been constructed in tank reservations too.

Although there is a hydro ecological value of the *Gasgommana* tank reservations, different kinds of impacts such as removal of the forest patches for constructing Agro-wells, expansion of the agricultural area towards the reservation, and collection of woody parts for agricultural purposes were identified. Further, physical damages to the reservation area due to machinery usages were also identified.

There was a negative correlation of Agro-well density of tank cascades and tree density of tank reservations. Further, the results revealed that with the increase of Agro-well density in tank cascades, correspondingly number of Agro-wells in tank reservations has also been increased. With that the percentage of *Gasgommana* land also has decreased within the tank cascades.

Therefore, it is clear that although the Agro-well development generally shows positive impacts on agricultural productivity and regional economy, uncontrolled expansion of Agro-wells has degraded the tank reservations in tank cascade areas of the dry zone of Sri Lanka.

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References

Aheeyar, M.M.M., and Ariyabandu R.D.S. (2002), "Socio-economic Issues Pertinent to Agro-well Farming in Sri Lanka". In Pathmarajah, S. (ed), *Use of Ground Water for Agriculture in Sri Lanka* - Symposium Proceedings, Agricultural engineering society of Sri Lanka, Peradeniya.

Dharmasena, P.B. (1998), "Resource Management Studies on Agro-well Farming in the Dry Zone of Sri Lanka" – *Project Terminal Report*, Field crops research and development institute, Mahailluppallama.

Dharmasena, P.B., and Goodwill I.M (1999), "Use of Ground Water in Minor Tank Irrigation Schemes of Sri Lanka". *In Proceedings of 17th International Congress on Irrigation and Drainage*, Granada, Spain pp.75-194.

Govt. of SL. (1979), Agrarian Services Act, and Agrarian Service Revised Bill 2006-43-1

Govt. of SL. (2000), Agrarian Development Act, No. 46 of 2000.

Govt. of SL. (2006), the National Land Use Policy (Drafted Act in 2006)-iii – 7

Jinapala, K., *et al*., (2003), "Multi-Level Participatory Consultative Approach for Institutional Change in River Basins" (Working Paper 59), International Water Management Institute, Colombo.

Kikuchi, M. *et al.,* (2003), "Agro-well and Pump Diffusion in the Dry Zone of Sri Lanka" (Research Report–66), International Water Management Institute, Colombo, pp. 1-25.

Marambe, B., Pushpakumara, G., Silva, P. (2012), "Biodiversity and Agro biodiversity in Sri Lanka: Village Tank Systems". In: Nakano, S.I., Yahara, T., Nakashizuka, T., Yamamoto, S. (Eds.), Biodiversity Observation Network in the Asia-Pacific Region. Springer, Japan, pp. 403-430.

Madduma Bandara, C.M., *et al.* (2010), "Scientific validation of some traditional land and water management practices under Village Tank Cascade Systems", in *Economic Review,* Vol. 36, People's Bank, Colombo.

Panabokke, C.R., et al. (2002), *Small Tanks in Sri Lanka-Evolution, Present Status and Issues*, International Water Management Institute, Colombo.

Pathmarajah, S., (2002), "Use of Groundwater for Agriculture in Sri Lanka", In Pathmarajah, S. (ed), *Use of Ground water for agriculture in Sri Lanka* -Symposium Proceedings, Agricultural engineering society of Sri Lanka, Peradeniya.

Perera, M.P. (2010), *Irrigation Heritage of Sri Lanka* (Sinhala Version), Center for Environmental Justice, Colombo.

Perera, M.P., and Nianthi, K.W.G.R. (2016), "The Impact of Agro-well Development on Floral Diversity in Tank Cascades in the Dry Zone of Sri Lanka", in *International Journal of Science and Research (IJSR)*, Vol.5 No 6, DOI: 10.21275/v5i6.NOV164764

Perera, M.P. (2017a), "Groundwater Exploration for Agro-well Development in Sri Lanka and the Current Status", in *International Research Journal of Human Resources and Social Sciences* (IRJHRSS), Vol. 4 NO 8, pp. 359-373.

Perera, M.P., (2017b), "Evolution of Tank Cascade Studies of Sri Lanka", in *Saudi Journal of Humanities and Social Sciences* (SJHSS), Vol. 2 No 7, pp. 597-610. DOI: 10.21276/sjhss

Perera, M.P. (2017c), "Stream Reservations are at Risk?: A Case Study on the Agro-well Development in the Dry Zone of Sri Lanka", *International Journal of Science and Research (IJSR)*, Vol.6 No 6, DOI: 10.21275/ART20174619

Ratnatunga P.U. (1970), *Sri Lanka Wewas and Reservoirs Album*, Sri Lanka Freedom from Hunger Campaign, Colombo.

Senaratne, A. (2002), "Groundwater Exploration in Sri Lanka", in Pathmarajah,s.(ed), *Use of Groundwater for Agriculture in Sri Lanka* - Symposium Proceedings, Agricultural Engineering Society of Sri Lanka, Peradeniya.

Wijesundara, W.M.G.D., Nandasena K.A. and Jayakody A.N. (2012), "Seasonal and Spatial Variations of N,P,K, and Cd Concentrations in Water of the Mahakanumulla Cascade in the Dry Zone of Sri Lanka", in Twenty Fourth Annual Congress Proceedings, PGIA, Peradeniya, p. 41.