

The Impact of Agro-well Development on Floral Diversity in Tank Cascades in the Dry Zone of Sri Lanka

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Abstract: *The dry zone farmers of Sri Lanka have no choice but to sustain the perennial crops in the long dry period (common to the dry zone) without a use of supplementary irrigation or groundwater resources. The emergence of Agro-well based agricultural systems has been common to the North Central dry zone since the 1980s decade. There is a common believe that the Agro-well based land development projects have drastically changed the overall land use of tank cascades in the dry zone. With this contextual impression, a number of scientists emphasized that there would be serious issues on biodiversity of the cascades. But some of them emphasized that to prove this argument further research is essential. Accordingly, this floral survey has conducted and computed the Simpson's Diversity Index to compare the diversity impact between low Agro-well density and high Agro-well density cascades in the selected mini-basins of the dry zone. The results revealed that the floral diversity impacts were not at the significant level.*

Keywords: Agro-wells, Floral diversity, Tank cascades, Dry zone.

1. Introduction

Groundwater exploration for the agricultural purposes of the dry zone of Sri Lanka was a reality, and "Agro-wells" were introduced in order to provide access to shallow groundwater. It was an attractive solution for the dry zone farmers to cultivate throughout the year. Since 1989, the expansion of Agro-wells was a recognized agenda for both Governmental and Non-Governmental Organizations [3]. The diffusion of Agro-wells in low land areas of river basins as well as within the "Tank Cascades" has been a significant level.

The dry zone river basins including mini basins of Sri Lanka consisted of complex tank systems from the 1st century B.C. (Brohier, 1934) [1]. These tank systems have been identified as "Tank Cascade Systems" by Madduma Bandara (1985) [6]. After the Ratnatunga's (1970) [11] "Eco-Village" concept many studies started to describe the Ecological/Biological status of these tank systems. Madduma Bandara (2009) [7], and Dharmasena (2010) [5], revealed that the tank ecosystems play a vital role in the dry zone environment including the maintaining of biodiversity.

However, the Agro-well based land development in the vicinity of tanks has been increased very rapidly. The immediate changes of the tank cascade landscape due to Agro-well development may be a serious issue with the aspect on bio-diversity. Owing to the complex vegetation types in tank cascades, the diversity of both fauna and flora becomes generally high (Madduma Bandara 2009[7], Dharmasena 2010[5], Perera 2010[10]) as it provides a variety of food resources and resting and nesting/breeding sites. Degrading of flora and fauna communities, loss of fertile lands and destruction of the village ecosystems, are the most distinct factors that have affected the tank cascade systems of Sri Lanka. The most heavily affected areas are the use of traditional knowledge on conservation and sustainable utilization of biodiversity. The tank systems

contribute to biodiversity and provide mixed, heterogenous landscapes: small tanks, irrigated paddy fields, forests, and villages (Marambe et al. 2012) [9].

Madduma Bandara (2009) [7], and Dharmasena (2010) [5] have explained that, the various development activities including Agro-well development, degrading of flora and fauna communities, loss of fertile lands, destruction of the village ecosystems, were the most distinct factors that have affected the tank cascade systems of Sri Lanka. Further, Marambe *et al.* (2012) [9] revealed that during the past few decades there has been a drastic reduction in forest cover and degrading of flora and fauna communities due to various development activities in tank cascades.

In view of that, the general opinion is the recent agricultural changes including Agro-well development have affected the floral diversity in tank cascade systems. Therefore, this study examined this perspective by comparing the floral diversity between high Agro-well density cascades and low Agro-well density cascades. Accordingly, the hypothesis of the current test was "Agro-well development causes the degradation of floral diversity in tank cascades".

2. Methodology

Conducted a floral survey and analyzed the diversity status using Simpson's Diversity Index. Among the floral category of „Seedling, Sapling and Trees“, the "Trees" (H = >1 m & DBH = > 5 cm) were selected for the current survey. The study was conducted covering two river basins namely; *Malwathu Oya* basin and the *Yan Oya* basin in the dry zone of Sri Lanka. A couple of tank cascades from two river basins were randomly selected considering similar resource conditions except the Agro-well density.

Table 1: Status of selected tank cascades from Malwathu Oya basin

Volume 5 Issue 6, June 2016

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Category	Halmillawewa tank cascade (Agro-well density-Low)	Periyakulama tank cascade (Agro-well density-High)
Residential families	123	135
Number of floral lands use types	7	7
Agro-ecological region	DL 1 (Dry low lands)	DL 1 (Dry low lands)
Mean annual rainfall	1250-1400 mm.	1250-1400 mm.
Average depth to bed rock	6 m-6.5 m	6 m-6.5 m
Average slope percentage	1 %	1 %
Soil grade	Medawachchiya-Aluthwewa-Divulwewa-Hurathgama-Kahatagasdigiliya-Association (No-37)	Medawachchiya-Aluthwewa-Divulwewa-Hurathgama-Kahatagasdigiliya-Association (No-37)
Agro-well density	5.4 per/km ²	22 per/km ²

Source: Agrarian service departmental documents and field study, 2013

Table 2: Status of selected tank cascades from Yan Oya basin

Category	Rambewewa tank cascade (Agro-well density-Low)	Belikulama tank cascade (Agro-well density-High)
Residential families	46	39
Number of floral lands use types	7	7
Agro-ecological region	DL 1 (Dry low lands)	DL 1 (Dry low lands)
Mean annual rainfall	1250-1350 mm.	1250-1350 mm.
Average depth to bed rock	6 m- 6.5 m	6 m-6.5 m
Average slope percentage	2 %	2 %
Soil grade	Medawachchiya-Aluthwewa-Divulwewa-Hurathgama-Kahatagasdigiliya-Association (No-37)	Medawachchiya-Aluthwewa-Divulwewa-Hurathgama-Kahatagasdigiliya-Association (No-37)
Agro-well density	1.1 Per/km ²	19 Per/km ²

Source: Agrarian service departmental documents and field study 2012

The proportionate stratified sampling method (stratified sampling method according to the land percentage) was used for the data collection. These land categories were Riverine forest strips, Highland forest patches, Kattakaduwa, Gasmomma, Home gardens, Chena lands and Agro-well lands. The percentages of the floral/tree land uses were calculated except the tank water surface and paddy fields in each cascade. The sampling plot size was 400 m² (20 m by 20 m). However, practically it was difficult to find a 20 m by 20m plots in riverine forest strips and Kattakaduwa tank reservation. Therefore, 400 m² requirements were completed using 10 m by 40 m sample plots.

The tree survey was conducted (by a five-member group, including two senior farmers) to identify the common names of rare tree species. Some of the tree species with scientific names were identified with the help of the academics (biologists) of the Faculty of Agriculture, University of Peradeniya. The collected data of individual trees and number of species were analyzed to determine the status of floral diversity using the ‘‘Simpson’s Diversity Index’’.

Simpson's Diversity Index (D)

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

1 - D (The value of this index ranges between 0 and 1 and the greater value show the greater sample diversity)

n = the total number of organisms of a particular species

N = the total number of organisms of all species

This method was used to identify the diversity status of high Agro-well density cascades and low Agro-well density cascades. Then the status of floral diversity of tank cascades was compared among the high Agro-well density cascades and low Agro-well density cascades in two river basins. Finally, a significant test was conducted to test the level of significance and to test the hypothesis.

3. Results and Discussions

3.1 Status of the floral diversity - Malwathu Oya basin

Halmillawewa cascade
(Low Agro-well density/5.4 per/km²)

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

SPs. =44
 N= 213
 $\sum n(n-1) = 2802$

D = 2802 / 213 (212)
 D = 2802 / 45,156
 D = 0.062
 1-D = 1- 0.062

Diversity Index = 0.938

Periyakulama cascade
(High Agro-well density/22 per/km²)

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

SPs. =47
 N=232
 $\sum n(n-1) = 4050$

D=4050/232 (231)
 D=4050/53,592
 D=0.075
 1-D=1-0.075

Diversity Index = 0.925

In the Halmillawewa cascade (Low Agro-well density), 44 tree species and 213 individual trees have been identified. The diversity index was 0.938. The reason for the higher diversity was the rich diversity level of the „Gasgommana’ and „Highland forest patches“. 32% and 30% of the total species have been recorded from these land use types respectively.

In the Periyakulama cascade (High Agro-well density), 47 tree species and 232 individual trees have been recorded. The diversity index was 0.925. Although this cascade consisted of 144 Agro-wells, the reason for the higher diversity was high tree diversity in „Agro-well lands“. 34% of total species have been recorded in Agro-well lands. In addition to that, 32% of the total species recorded from the „riverine forest strips“. Accordingly, both cascades in the *Malwathu Oya* basin have shown higher diversity values.

The same analysis technique was applied to the floral survey data of the Yan Oya basin cascades.

3.2 Status of the floral diversity – Yan Oya basin

Rambewewa cascade
 (Low Agro-well density/1.1 per/km²)

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

SPs. =54
 N=265
 $\sum n(n-1) = 4266$

D=4266/265 (264)
 D=4266/69,960
 D=0.061
 1-D=1-0.061

Diversity Index = 0.939

Belikulama cascade
 (High Agro-well density/19 per/km²)

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

SPs. =52
 N=297
 $\sum n(n-1) = 3962$

D=3962/297 (296)
 D=3962/87,912
 D=0.045
 1-D=1-0.045

Diversity Index = 0.955

In the Rambewewa cascade (Low Agro-well density), 54 tree species and 265 individual trees have been recorded. The diversity index was 0.939. Major reason for the higher diversity was rich diversity level of the „Highland forest“, which represented 56% of the total diversity. Further 24% and 20% of the diversity have been represented in the „Gasgommana“ and „Kattakaduwa’ land uses respectively.

In the Belikulama cascade (High Agro-well density), 52 tree species and 297 individual trees have been recorded. The diversity index was 0.955. Although this cascade has been a high Agro-well density cascade, the reason for the higher diversity was high tree diversity in „Agro-well lands“. 65% of total species has been recorded in Agro-well lands. In addition, 25% of the total species were recorded from the „riverine forest strips“. Accordingly, both cascades in the *Yan Oya basin* too, have shown higher diversity values.

3.3 Comparison of the floral diversity value among high Agro-well density cascades and low Agro-well density cascades of two river basins:

The difference of Simpson’s Diversity values between high Agro-well density cascades and low Agro-well density cascades were compared, with the aim of identifying the floral diversity difference.

Table 3: Simpson’s diversity index values of high Agro-well density cascades

Name of the cascade	Agro-well density (per/km ²)	Simpson’s diversity Index value
Periyakulama	22	0.925
Belikulama	19	0.955

Table 4: Simpson’s diversity index values of low Agro-well density cascades

Name of the cascade	Agro-well density (per/km ²)	Simpson’s diversity Index value
Halmillawewa	5.4	0.938
Rambewewa	1.1	0.939

The study revealed that both types of cascades have high diversity values, with a small range of difference. Therefore, a significant test was conducted to examine whether these differences are significant or not.

Table 5: Difference Mean T-Test for Simpson's diversity values

	High Agro-well density	Low Agro-well density
Mean	0.9400	0.9385
SD	0.0212	0.0007
Number of groups	2	2

P value and statistical significance:

In the two-tailed test, the P value equal to 0.9344.

By conventional criteria; this difference was considered to be not statistically significant.

Accordingly, this test revealed that there was no significant difference of floral diversity between the high Agro-well density cascades and low Agro-well density cascades.



Figure 4: Land use pattern of the Agro-well based lands



Figure 5: Floral diversity of Agro-well based lands

4. Conclusion

The Simpson's Diversity Index values have shown that floral diversity of both types of cascades (Agro-well density low & high) was high. Within the low Agro-well density cascades in both *Malwathu Oya* and *Yan Oya* basin, the floral diversity was high (Simpson's Diversity Index = 0.938 & 0.939) due to the diversity of "highland forest patches" and "tank reservations". As same as the floral diversity was high, in high Agro-well density cascades (Simpson's Diversity Index = 0.925 & 0.955). The reason was that floral diversity was rich in "Agro-well based lands" (represented 32% & 65% of diversity), in addition to the riverine forest strips in

high Agro-well density cascades. The floral diversity of high Agro-well density cascades and low Agro-well density cascades were not revealed a significant difference, according to the significant test.

According to the above findings, the hypothesis of this test that "Agro-well development causes the degradation of floral diversity in tank cascades" can be conceptually rejected. Consequently, the Agro-well development may not cause degradation of floral diversity in tank cascades.

5. Future Research Directions

Few studies have revealed that forest cover of some tank cascades had been removed before the expansion of Agro-wells (Perera, 2010) [10]. With the evolution of Agro-well land development in these degraded areas of tank cascades, a number of diverse perennial crop gardens can emerge. Although this results relevant to the current background of highland areas of tank cascades, the stream reservations, and separate ancient tank reservations could be damaged due to the Agro-well land development. Therefore, the attention of the future studies should go to this research area too.

6. Acknowledgments

Authors gratefully acknowledge the financial supports given by the following Institutions.

- 1) International Research Centre, University of Peradeniya, Sri Lanka
Grants Reference Number: InRC/RG/13/06
- 2) National Centre for Advance Studies in Humanities and Social Sciences, Sri Lanka.
Grants Reference Number: 14/NCAS/PDN/Geo/37

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